A PRACTICAL TREATISE

ON THE

MANUFACTURE

OF

WORSTEDS AND CARDED YARNS:

COMPRISING

PRACTICAL MECHANICS, WITH RULES AND CALCULATIONS APPLIED TO SPINNING; SORTING, CLEANING, AND SCOURING WOOLS;

THE

ENGLISH AND FRENCH METHODS OF COMBING, DRAWING, AND SPINNING WORSTEDS AND MANUFACTURING CARDED YARNS.

TRANSLATED FROM THE FRENCH OF

CHARLES LEROUX,
MECHANICAL ENGINEER AND SUPERINTENDENT OF A SPINNING MILL.

BY

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AND

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ILLUSTRATED BY TWELVE LARGE PLATES.

TO WHICH IS ADDED

AN APPENDIX,

CONTAINING EXTRACTS FROM THE REPORTS OF THE INTERNATIONAL JURY, AND OF THE ARTISANS SELECTED BY THE COMMITTEE APPOINTED BY THE COUNCIL OF THE SOCIETY OF ARTS, LONDON,

ON

WOOLLEN AND WORSTED MACHINERY AND FABRICS, AS EXHIBITED IN THE PARIS UNIVERSAL EXPOSITION, 1867.

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PREFACE.

THE volume here presented to the American public is the production of a gentleman in every way competent to prepare such a treatise, and it is believed that it will be found to be clear, methodical, thorough, and useful, as well as a faithful translation.

The branch of industry which it illustrates, and to which it is an important adjunct, is now one of the leading interests of this country. By the census of 1860, it appears that there were then in the United States 1263 woollen and worsted mills, and 712 wool-carding establishments. In 1864 the total production of woollens was estimated in value at $120,000,000.

Through the combined influences of the war, and the high price of gold, and more recently by reason of the amendment and increase in the tariff of duties on wools and manufactures of wool, this industry has received a remarkable impulse.* This is eminently the case in the Western States, where many among the more intelligent and far-seeing men, have become fully aroused to the importance of a thoroughly diversified industry, and especially to that of developing the wool interest, and are fast moulding public opinion into a firm belief in the policy of protection on broad economic and national grounds.

* " EFFECTS OF THE TARIFF.—An extensive and very experienced wool broker in New York—one of the large hearted and liberal men in that business—thus writes us : ' Sheep husbandry was never on so good a base as it is now. In Europe fine wool was never so cheap—fair Mestiza being at five to five and a half pence, and Cape at six to seven pence. Where would our wool growers be if not protected ? The stock of fine clothing wool in Europe is terrific.' "—HON. H. S. RANDALL, *in "Moore's Rural New Yorker," Nov.* 14, 1868.

In the seven States of Ohio, Michigan, Indiana, Illinois, Wisconsin, Iowa, and Minnesota, the woollen manufacturing establishments have increased from 259 in 1860 to 557 in 1868. The result is, that it is now believed that they produce within their borders more woollen goods than they actually consume, and at the Wool Exposition, in Chicago, in August, 1868, the important statement was made that "in the course of the wool trade for the past five years, Chicago, Detroit, and Milwaukee have constantly proved better markets for the raw material, freight and expenses being added, than Boston, New York, and Philadelphia."

This grand movement is one full of interest and promise, not alone to these States, but to the people of the entire country. If we are ever to be emancipated from our financial and industrial vassalage to Europe—if we are ever to see the day when we may safely and permanently resume the use of gold and silver as the currency of the land, it must be accomplished by the development of our own industry—we must produce and sell more and buy less. Then, as a consequence, will follow an accumulation in the country of the precious metals, which will be found to be the one and only true road to "resumption," a result not to be arrived at by any system of "contraction." In a word, before we can have less paper, we must have more gold and silver, and we must owe less abroad. No branches of our industry are of more vital importance in this connection than those of textile fabrics, our imports of the manufactures of cotton, flax, silk, and wool for the year ending December 31, 1867, having been of the value of $94,287,999, of which the manufactures of wool comprised $37,152,985, both in gold valuation.

M. Leroux's book may be divided into five principal parts:—

I. Principles of mechanics applied to woollen manufacture, in order to enable the operator to calculate accurately the velocities required by the various pieces of his machinery, vary

the pressures of the top rollers according to the staple of the wool and the yarn to be manufactured, &c.

II. The properties and nature of the principal sorts of wool found in the market, and the processes for sampling, washing, and scouring any kind of wool preparatory to its treatment, whether for combed or carded yarns.

III. The French method of making worsteds (combed yarns), which differs from the English mode of operating, especially in the drawing processes, where the sliver is never twisted, but is only drawn out, at the same time that the fibres are constantly kept in a state of parallelism by passing over a circular comb (porcupine).

IV. The English method of making worsteds, where the slivers are twisted at each operation.

V. The manufacture of carded wool, which is about the same in both countries, except at the last stage of the operation, when peculiar styles of throstle frames are used instead of the mule.

In it we also find numerous tables, which indicate the intervals between the drawing rollers and the porcupines, the number of teeth of change pinions, the proportion of oiling material, the weights for top rollers, &c. &c., which are the best adapted for each kind of wool and a given yarn. These tables, the result of long experience, will evidently prove very useful.

We were in doubt whether to cause to be translated into English weights and measures the figures of the French text; but, after a careful study of the book, we have come to the conclusion that such a transformation would disfigure the simplicity and beauty of the decimal system of calculation.

We have therefore placed at the end of the volume tables, and ready made calculations, by which the reader will be enabled to transform, when desired, the figures of the text into the corresponding English weights and measures.

The decimal system is already so widely diffused, that we see

it adopted exclusively in many English and German scientific and practical publications, for the sake of its simplicity. Those of our readers who are accustomed to calculate in *dollars* and *cents*, will soon understand how to measure in *metres*, *decimetres*, *centimetres*, and *millimetres*, and certain figures of approximate value, retained in the memory, will prove a great aid in the practice of this system.

For instance: 1 decimetre = 10 centimetres = exactly 3.937 inches, which we may set down as 4 inches.

1 metre	=	approximatively 40 inches.
"	=	" $1\frac{1}{10}$ yard.
1 inch	=	$2\frac{1}{2}$ centimetres.
"	=	25 millimetres.
1 kilogramme	=	2.2 pounds avoirdupois.
"	=	$2\frac{1}{5}$ " "
1 gramme	=	about 15 grains.
1 litre	=	about 1 quart.
1 square metre	=	about 11 square feet.
1 cubic "	=	" 35 cubic feet.

It will be well now to see what will be the English number, and the weight per hank of a French woollen yarn measuring 310,000 metres per kilogramme.

In the French method of numbering, No. 1 yarn = 1000 metres weighing 1000 grammes (1 kilogramme).

No. 2 = 2000 metres weighing 1000 grammes.
No. 310 = 310,000 " " " "

Remembering that a pound avoirdupois = 453 grammes, we have the proportion:—

If 1000 grammes contain 310,000 metres, 453 grammes will contain x metres, whence x = 140,430 metres.

But 140,430 metres = 153,578 yards, which is the length of that yarn for one pound avoirdupois.

560 yards of woollen yarn make a hank; therefore—

$\frac{153578}{560} = 274\frac{1}{4}$ hanks to the pound; and the pound being equal

to 7000 grains, we have $\frac{7000}{274.25}=25.5$, or twenty-five grains and a half for the weight of a hank of that yarn, or 1 grain for 22 yards.

It has been deemed desirable to add to this treatise such facts in connection with the Paris Exposition of 1867 as would throw light upon the latest and most important improvements in woollen machinery, manipulation, and fabrics. With this object in view, a translation has been made from appropriate parts of the official publication, the "Rapports du Jury International," and extracts have been given from the admirable Report of Mr. John French, of Bradford, to the Society for the Encouragement of Arts, Manufactures, and Commerce, London, neither of which it is believed can fail to prove interesting and valuable to practical men.

The publisher with pleasure embraces this opportunity to return his thanks to the Society of Arts as well as to Messrs. Bell & Daldy, publishers, London, for permission, very kindly and promptly given him, to republish the report of Mr. French.

H. C. B.

PHILADELPHIA, Nov. 25, 1868.

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A PRACTICAL TREATISE

ON THE

MANUFACTURE OF WORSTEDS AND CARDED YARNS.

INTRODUCTION.

GENERAL GLANCE AT THE ART OF SPINNING WOOL.

Spinning is an art of great antiquity, indeed one of the earliest industrial pursuits of the human race. It was practised even in the age of fable, as illustrated by the familiar myth of Hercules spinning at the feet of Omphale. The art was at one time the exclusive prerogative of queens, and among most nations even its invention, so precious to mankind, has been attributed to women. The Egyptians believed it to be due to the goddess Isis; the Chinese, to the wife of Yao, their earliest emperor; the Hindoos ascribed the honor to Arachne; the Greeks, to Minerva; the Peruvians, to Mama-Oella, wife of Mamo-Capac, their first king; but, according to the naturalist Pliny, the inventor of the distaff and spindle was Closter, the son of Arachne.

In the beginning, men clothed themselves with the bark of trees, with leaves, or with rudely interlaced reeds; subsequently they resorted to the skins of animals; such

raiment, however, was imperfect and awkward, and at length they were compelled to search for something at once warm and more convenient. It was at this period, then, that means were sought to separate the fur or the wool from the skins, and the materials thus obtained were agglutinated and felted by means of gummy substances and heat, and finally transformed into habiliments. Felted clothing was indeed very greatly used among the ancients. Still, it was not until long afterwards that the idea was entertained of converting into yarn the fleece of sheep or the fur of beasts, and the textile bark of plants, such as flax and hemp, or the down surrounding the fruit of certain trees, like the cotton-tree.

There are at this very day, in the nineteenth century, races who are ignorant of the uses of yarn or thread. The Greenlanders use for sewing a material made from the bowels of seals. The Samoyedes and Esquimaux employ the tendons of animals.

Nevertheless, many centuries have elapsed since mankind first discovered the art of twisting and securing a quantity of the fibrillæ of animal furs or of the bark of plants to the end of a stick, and attaching to it a light weight, which, when turned by means of the fingers of the right hand, had the property of incorporating them into a continuous thread or yarn, the length of which depended upon the amount of textile material attached to the end of the stick. This invention of the distaff and spindle, we have before mentioned, is attributed to Closter; and during at least thirty centuries no other means of spinning were employed. In 1530 a baker of Brunswick invented the spinning-wheel, a much more

convenient and expeditious apparatus than the distaff and spindle.

In 1777, to the spinning-wheel and treadle was added a second bobbin, by the invention of M. Besnière, so that both hands could then be used in spinning, and consequently, the product of the operation was nearly double at the same cost in labor.

At the end of the last century, the art of spinning received a great impulse, thanks to the valuable inventions of MM. Dabo, Declanlieux, Laurent, Collier, and others.

In 1767, James Hargraves, a man of great ingenuity, invented the spinning-jenny, by means of which eight threads or yarns could be as easily spun as one, and which was eventually perfected to such an extent, that a child could keep eighty or a hundred spindles in motion. This happy invention immortalized Richard Arkwright. We are indebted to Crampton for the spinning mule, upon which great improvements have been made, rendering it an admirable apparatus for combed wool (worsted).

The spinning of worsteds has only been known in France during the past fifty years; and of carded and combed wool, at most for thirty-five. The spinning of carded wool was introduced from England between 1809 and 1813 by Messrs. John Cockerill, Douglass, and Lasgorsain. Since 1825, we have so perfected our appliances that, at the present day, the French are unrivalled in this branch of industry. The Saxons alone can enter into any competion with us, and even then, our yarn is found to be finer and better spun, as the Saxons can only attain to No. 60, while we, with the same qualities of wool, are able to spin No. 80 (French numbering).

It is, on the other hand, true that the English send yarn into the market at a lower price than ours, but this is the case only of the coarser numbers, and for this we will assign a reason when speaking of English spinning.

A convincing proof of the superiority of our method of manufacture over that of the English is, that they have vainly attempted to spin cashmere wool in fine numbers upon their frames. Their mode of preparing wools for the process of spinning is not adapted to those numbers. In France, the proceeds of spinning cashmere wool are estimated at six or eight millions of francs ($1,200,000 to $1,600,000); a part of the resulting yarn is used in Paris for the manufacture of cashmere and other kinds of shawls.

The rapid progress we have made during the last twenty-five years in woollen manufactures, especially in spinning combed wools (worsteds), has greatly contributed to the application of power looms to the weaving of woollen yarn. Wool is now no longer spun by hand. That branch of industry, which has rendered such service to mankind, has completely and for ever disappeared. The attempt, still made in certain provinces to compete by hand labor with machinery for spinning hemp, is futile.

At the same time that our learned mechanicians were occupied in perfecting the machinery for spinning wool, the breeders and manufacturers were at work, improving the breed of the varieties of sheep.

Spain, ever since the Middle Ages, has produced sheep bearing fine wool of the Tarentine breed, derived from the Romans, her former masters. M. le Président de la Tour d'Aigues, in 1758, purchased and brought home several rams of this breed, and was therefore the first to

introduce the merino sheep into France. In 1786, Spain conceded to us, by treaty, three hundred and sixty seven ewes of the finest flocks of Leon and Segovia, from which stock is derived the magnificent breed of Rambouillet.

By the treaty of Bale, in 1799, we received fifty five hundred ewes of the handsomest Castilian breed. With these ewes, six model establishments were formed on the plan of that at Rambouillet, and the remainder distributed to several land owners. This regeneration met with the most complete success, and from the year 1808 our manufacturers had no further recourse to Spanish wools. Unhappily, the disasters to which France was at that time subjected, proved a fatal blow to the improvement of our indigenous breeds. Most of our young merinos were sent to the shambles to supply the necessities of our armies. But since then, thanks to the liberal co-operation of the government, we are no longer tributary to a foreign market for the enormous quantities of wool we require to meet the requirements of our numerous manufactories.

Such, in a few words, is the history of the woollen industry in France, one which, each day, is assuming greater proportions.

We believe that we are rendering a real service to manufacturers and their foremen, by offering them a practical treatise upon the spinning of combed (worsted), carded combed, and carded wool, a sort of vade-mecum in which they may find all desirable information, and simplified calculations for daily use in a manufactory. The work contains also a description of all operations to which wool is subjected, from the time it leaves the sheep till it is converted into yarn, and of all the most recently invented machines employed in spinning.

The typical machinery upon which we shall base our reasoning, is a steam engine of twenty horse power, capable of moving three thousand spindles producing yarn varying from No. 20 to No. 60. The various instruments going to make up this arrangement are shown in the following table:—

Combed Wool (Worsted).		Combed Carded Wool.	
Number of machines.	Machines employed.	Number of machines.	Machines employed.
1	Willow for opening wool.	1	Willow for opening wool.
2	Beaters.	2	Beaters.
2	Scouring machines.	1	Burring (cleaning) machine.
1	Oiling machine	2	Scouring machines.
7	Breakers (cards.)	1	Picker.
1	Gill box.	1	Oiling machine.
1	Dressing (smoothing) machine.	14	Breakers (cards).
2	Combing machines of Holden.	1	Gill box.
1	Spooling machine.	1	Dressing (smoothing) machine.
1	Drawing frame 4 combs 2 spools.	1	Drawing frame 4 combs 2 spools.
1	" " 8 " 4 "	1	" " 8 " 4 "
1	" " 12 " 6 "	1	" " 12 " 6 "
1	" " 12 " 12 "	1	" " 12 " 12 "
1	" " 24 " 24 "	1	" " 24 " 24 "
1	" " 24 " 48 "	1	" " 24 " 48 "
1	" " 48 " 96 "	1	" " 48 " 96 "
15	Spinning mules—200 spindles.	15	Spinning mules—200 spindles.

Note.—This table is merely a glance at the principal apparatus necessary for the production of worsted and carded combed yarns; other kinds of machinery, such as throstles, doublers, &c., are mentioned hereafter.

The French wool spinners divide woollen yarns into four classes:—

I. Hand-combed yarns.

II. Machine-combed yarns (worsteds), when gills and combers (of Holden, Lister or others) are employed in connection with the drawing frames, each of which carries combs or porcupines.

III. Carded-combed yarns, when the above combers are dispensed with.

IV. Carded yarns, when made on the mule or throstle directly from rovings as they come from the finishing breaker.

PART I.

PRACTICAL MECHANICS APPLIED TO SPINNING.

CHAPTER I.

CHOICE OF A MOTIVE POWER.

It is important that every man charged with the direction of a spinning mill should be familiar with the mechanical questions which form the basis of this flourishing branch of industry, and we have, therefore, thought it but right, in the interest of manufacturers, to prefix to this treatise upon spinning a brief consideration of machinery, as applied to that art.

The first question, which presents itself to us, is that of the motive power; for, in order to keep the apparatus of a spinning mill in motion, it is necessary to secure a motive power great enough to overcome all the resistances which are continually occurring in the manufacture of yarn. This motive power may be either a steam engine or a hydraulic wheel, the preference always remaining to the latter, by reason of its trifling running cost. We, of course, only refer to permanent water powers; for those established along small watercourses are not adapted to the uses of a spinning mill.

To steam-engines there is the great objection that

they consume a great quantity of coal, amounting with some of them to four kilogrammes an hour for each horse power. This enormous expenditure of fuel is especially a consequence of the little attention paid by engineers to removing the incrustation formed in the boiler, and hindering the transmission of heat. In order to prevent these incrustations, 5 kilogrammes of muriate of ammonia* (sal ammoniac), or some ammoniacal water produced in the distillation of pit-coal (this substance costing comparatively nothing), with the addition of a few potatoes, is mixed with the water of the boilers; and, by this means, calcareous matters are prevented from becoming fixed upon the inner walls.

Recently improved steam engines only burn 3 kilogrammes of English coal an hour, and for each horse power. M. Farcot supplies engines which expend less than 3 kilogrammes; but we should not rely upon the consumption of fuel of engines on trial, which is not at all the same as in their practical application.

In default of a good hydraulic motor, that of the steam-engine is the only one which realizes the desired conditions.

I shall not discuss at length the choice of engines adapted to a spinning mill; a good mean pressure condensing engine appears to me the most suitable in several respects, especially in a country where the water supply is near at hand; for, otherwise, we should have to resort to a high pressure engine, which consumes a quarter

* Muriate of ammonia has the defect of rusting not only the boiler, but also the steam-engine. Soda ash, and better still, caustic soda, extracts of logwood, &c., are good protectives. But the remedies should be applied according to the impurities of the water.—*Trans.*

more fuel than the mean pressure engine. This explains why most manufacturers choose the vicinity of water-courses as sites for establishing their mills. The mean pressure engine, while at work, throws off a great quantity of warm water, which is constantly used to advantage in a wool spinning mill, while in other manufactories it is in part wasted. This water may be conveyed into the large tank for supplying the washing room; and we shall describe the apparatus in the chapter relative to that subject.

It will be readily seen that the water having been already raised to a temperature of + 30° centigrade, it may be quickly and cheaply brought up to + 80° centigrade.

Arrangement of the Work Rooms.

A spinning mill should be established upon the following fundamental principles: 1. Solidity, that is to say, protection from the jarring produced by the motion of the machinery; 2. Salubrity, in other words rooms high and large enough to prevent the air from becoming foul; 3. Convenience, that is, apartments convenient for each operation.

Fig. 1, Pl. I. gives the plan of arrangement of the work rooms.

Arrangement of Machines.

The most heavy machines, such as breakers, dressing, scouring, and preparatory machines, are placed nearest the motive power, in accordance with their relative force.

The spinning mules are placed at the other extremity of the transmitting shaft, or in a room on the second floor, as is generally the case.

The store-rooms consist of: 1st, a wool-room with cases; 2d; a room for the combed and spun products.

The establishment I have described above is so arranged, that the wools received from the store-room can be carried directly through the beating and scouring processes, after which their course is determined by the motion of the machines in which they are worked. Thus, the products of the different operations do not come in each other's way in the various rooms, and are more readily and cheaply kept track of.

The store-rooms for the reception of wools are not put down on the plan.

The sorting-room is placed in one of the store-rooms, so that those engaged in the operation may handle the wools with greater convenience.

In conveying wools from the store-room to the beating or cleansing rooms, a small box car is used, in which are placed the wools. It generally carries about 60 kilogrammes, and is readily managed by one man without assistance. Four or five trips of this box car every day are sufficient to supply the mill.

CHAPTER II.

TRANSMISSION.

Driving Shafts.

The engines of a spinning mill should be so arranged that the shafts transmitting the power shall, in nowise, suffer from the resistance to be overcome.

To transmit motion properly to the different machines constituting the working stock of the mill, a driving shaft of turned iron should be introduced, reaching from the motive power to the extremity of the building in a straight line, and resting on a series of hangers about 3 to 5 metres apart.

This shaft, imparting motion to the machinery, should be well adjusted and perfectly level. There should also, at intervals, be arranged bearings resting accurately on boxes of iron or brass placed on the hangers, as well as pulleys with broad and flat faces for disconnecting and transmitting motion to the different machines. This shaft communicates with the driving engine by means of a belt or cast-iron wheels, furnished with cogs of very dry applewood, and of dimensions calculated from the absorbing power. The shaft is of greater or less diameter, according to the strain it may have to support at any given time.

It is very easy to determine the diameter of a shaft, when the strain it has to bear is known. We are in-

debted to M. Armengaud,* Sr., for a very useful table for computing the diameter of bearings, from the amount of strain they have to resist.

Table showing the Diameters of Bearings (journals) for Shafts submitted to torsional Strains.

Diameters in centimetres.	Cast Iron Shafts.			Wrought Iron Shafts.		
	1st mover.	2d mover.	3d mover.	1st mover.	2d mover.	3d mover.
1	6859.00	3375.00	1728.00	4096.00	2197.00	1090.00
3	254.04	125.00	64.00	132.00	81.36	37.00
5	54.87	27.00	13.82	32.70	17 56	8.00
6	31.75	15.62	8 00	19.90	10.17	4.62
7	20.00	9.84	5.04	12.20	6.11	2.91
8	13.32	6.59	3.57	8.00	4.29	1.95
9	9.41	4.63	2.37	5.62	3.13	1.37
10	6.86	3.38	1.73	4.10	2 20	1.00
12	3.98	1.95	1.00	2.37	1.50	0.57
15	2.03	1.00	0.51	1.21	0.65	0.29
18	1.17	0.58	0.30	0.70	0.37	0.17
20	0.86	0.42	0.22	0.51	0.26	0.13
24	0.50	0.24	0.13	0.30	0.16	0.07
25	0.44	0.21	0.11	0.26	0.14	0.06
26	0.39	0.19	0.10	0 23	0.13	0.05
28	0.31	0.15	0.08	0.19	0.10	
30	0.25	0.13	0.06	0.15	0.08	

In order to use this table, *divide the number of revolutions of the shaft per minute by the number of horse-power employed; then look in the columns of the table for the number which most nearly approximates the quotient thus obtained, bearing in mind, of course, the material of the shaft; the number corresponding in the first column will give the diameter in centimetres.*

* *L'Ingénieur de poche,* by Armengaud, 23 Boulevard de Strasbourg, Paris.

1st Example.—What would be the diameter of a wrought iron journal or bearing submitted to the strain of 15 horse-power, and making 100 revolutions a minute (1st mover, shaft of the fly-wheel)?

$\frac{100}{15} = 6.66.$ The nearest corresponding number is 8 centimetres ($0.^{m.}08$ or 0.08 metre), which is the proper diameter of the journal.

2d Example.—What diameter should be given to a shaft bearing of wrought iron (2d mover), making 100 revolutions a minute, and submitted to a strain of 15 horse-power?

$\frac{100}{15} = 6.66.$ The nearest figures to 6.66 are 6.11; in other words, the bearing should have a diameter of 7 centimetres.

3d Example.—What shall be the diameter of a wrought iron bearing (3d mover), the shaft making 100 revolutions a minute, and resisting the strain of 8 horse-power?

$\frac{100}{8} = 12.5.$ The nearest number is 8, for which we find 5 centimetres, which is the diameter to be given to the bearing.

A velocity of 100 revolutions a minute is the most suitable one, there being less loss than with a velocity of 50 revolutions, for example.

The bearings or journals are suppled with collars, or shoulders to prevent oscillations which would soon destroy the brasses. These bearings should also be accu-

rately turned and polished, as well as the surfaces of the cushions which receive them. If these precautions were not amply taken, friction would occasion gumming, development of heat, and danger from fire would ensue.

The journals are generally oiled by hand, by means of a small can. This method of oiling is inconvenient, especially for the men who have to attend to it, and is costly, without answering the desired object.

I will remind the public that the universal exhibition of Paris, in 1855, offered several systems for mechanical oiling, and would recommend particularly for spinning mills the apparatus of M. Coquatrix (Fig. 3, Pl. I.), which is very simple, being of flint glass and easily obtained.* It is screwed on to the cap of the pedestal, and will contain enough oil to last fifteen days, besides allowing the flow of oil to be regulated at will, and its level to be ascertained at sight. One of the principal advantages of this contrivance is, that the oil is kept from contact with the dust and waste arising from the materials in process of manufacture.

CHAPTER III.

Belts.

The driving pulleys fixed upon the shaft should be well centred, so that there may be no inequality of motion which would destroy the belts.

To transmit motion to the apparatus without noise or

* M. Coquatrix, 40 Rue de la Charité, Lyons.

loss of power, tanned leather belts of first quality are preferably used. They wear one and a half times as long as those of inferior qualities, which, although their low price is an inducement to purchasers, are more expensive in the end, by the stretching and rapid deterioration they undergo.

Means of Determining the Dimensions of Belts.

The greater or less thickness of belts often contributes to their stretching and the continual variations to which they are subject, while extended over the circumference of pulleys or drums.

For high powers, well tanned leather of sufficient thickness should be preferred. I have prepared the following table, which gives the thicknesses of belts calculated from the variable power of machinery, and the diameters of pulleys.

Thicknesses of Belts, Calculated from the Power they have to Transmit.

Number of horse power.	Thickness in millimetres, the pulley's diameter being at least $= 0^m.30$.	Thickness in millimetres, the pulley's diameter being at least $= 0^m.20$.
½	5½	5
1	6	5½
2	6½	6
3	7	6½
4	7½	7
5	8	7½
6	8½	8
7	9	8½
8	9½ doubled belt	9 doubled belt
9	10 " "	9½ " "
10	11 " "	10 " "

It is rare that a force of over ten horse-power is transmitted by means of belts.

For a force of eight to ten horse-power, the straps should be double, which prevents their stretching; that is to say, two straps are superposed and sewed together at their edges. Thus, for a nine horse-power two belts are sewed together, one of which is one millimetre thicker than the other;

5.5 below
4.5 above

10.0 millimetres are the thickness of a belt which will resist the action of this power and even a greater one. For low powers, the thickness is always from four to five millimetres.

The transmission of motion from one shaft to another, by means of belts, depends entirely upon the friction produced by their tension upon the pulleys or drums, around which they are made to move. If the force to be transmitted by them is augmented, the friction is in like manner increased; and if, in that case, the tension of the belts remains the same, their friction surface, or what amounts to the same thing, their breadth, must be increased.

For instance, if we desire to impart an amount of motion, for which the requisite power is represented by 7; and if the width of the belt is represented by 10, and the velocity by 100; it is evident that to transmit double the force, represented therefore by 14, the width will have to be 20 with a velocity of 100, or 10 with a velocity of 200; or, in other words, that we require a width and velocity such that their product shall be to the force employed as 2 : 1; whence it is deduced: *that the powers*

to be transmitted are to each other as the product of the width of the belts multiplied by the velocity.

M. le Général Morin, Director of the "Conservatoire des Arts et Métiers" at Paris, where he pursues a course of lectures in industrial mechanics, has found that belts of tanned leather will resist a tension computed at 2 kilogrammes for every square millimetre of their section.

We refer the reader, for this subject, to the valuable work itself (*Aide-mémoire de Mécanique*) of the illustrious professor, where are given not only the results of experiments, but also theories tending to substantiate these experiments themselves. As algebraic calculations are not embraced in the plan of this book, we have thought it unnecessary to insert them.

We have limited ourselves to the following table, which gives the suitable widths of belts, computed from the strain to which they are subjected. We are indebted for this table to M. Armengaud, whose numerous and learned researches have rendered great service to the mechanical art.

Table for Ascertaining the Width of Belts.

Velocity per minute in metres.	Width of belts (tanned leather) in millimetres. (Force in horse power.)						
	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{5}{10}$	$\frac{9}{10}$	One horse power.	Two horse power.	Three horse power.
20	68	132	328				
30	44	88	220	394			
40	34	66	164	296			
50	26	53	132	237			
60	22	44	110	197	220	440	
70	19	38	94	170	188	377	565
80	17	33	82	148	165	329	494
90	15	29	73	132	147	293	440
100	13	26	66	119	132	264	396
120	11	22	55	99	120	220	330
140	9	19	47	85	94	188	283
160	8	17	41	74	82	165	247
180		15	37	66	73	147	220
200		13	33	55	66	132	198
240		11	28	47	55	110	165
280		9	24	41	47	94	141
300		8	22	39	44	88	132
360			18	33	37	73	110
400			16	28	33	66	99
500			13	24	26	53	79
600					22	44	66
700						38	56
800							50
900							44
1000							40
1200							33
1500							26
2000							20

When it is desired to determine the width of a certain belt, *multiply the number of revolutions of the pulley or drum, made in one minute, by its circumference, and the product will express in metres the desired velocity.* The width, in millimetres, will then be found opposite this number, and in the column of the given power. If pul-

leys, however, are not in the relation of identical diameters, but are in the relations about to be mentioned, then *multiply the width, given in the preceding table, by the coefficient of transformation.*

Coefficient of Transformation of the Width of Belts according to the Relations of the Diameters of Pulleys.

For pulleys, the diameter of which are to each other as 1 : 2, the width indicated in the table will be multiplied by 0.75. For the ratio of 1 : 3, the multiplier will be 0.65; and for the ratio of 1 : 4, 0.58.

Required the width of a belt transmitting one horse-power, and supposing it mounted on a pulley or drum of 0.40 metre (40 centimetres) in diameter, making 120 revolutions a minute, and driving another pulley of 0.80 metre in diameter:—

$0.^{\mathrm{m}}40 \times 3.1416 \times 120 = 150.79$ metres velocity.

By consulting the table already given, it will be seen that the velocity $150.^{\mathrm{m}}79$ corresponds, for one horse-power, to a width of belt of about 85 millimetres; but, as the ratio of the pulley of $0.^{\mathrm{m}}40$ to that of $0.^{\mathrm{m}}80$ is that of 1 to 2, we multiply $0.^{\mathrm{m}}085$ by 0.75.

Now, $0.^{\mathrm{m}}085 \times 0.75 = 0.^{\mathrm{m}}06375$; and so, the width of the belt will be $0.^{\mathrm{m}}06375$, or between 6 and 7 centimetres (60 to 70 millimetres).

Experience shows that belts ought never to be less than 20 millimetres wide, as they are subject to stretching and breakage. Their width should also exceed that ascertained from the table, by at least one-sixth. Machines working different materials, with varying

quantities, undergo more or less strain. Thus, a spinning mule, after having worked ten hours, absorbs one-fifth more power than at the outset. Wet weather occasions the same effect; while obstructions, want of oiling, materials more or less difficult to spin, &c., are so many causes which have to be neutralized by developing the friction surfaces of the belts.

Loss of Velocity suffered by Belts while in Motion

The variable length of the belts has an influence upon their slipping; when they are crossed, they are less liable to slip.

The loss of velocity suffered by belts, when mounted, depends upon their friction surface; for, the greater the surface embraced, the less will be the loss; and conversely, the less the surface embraced, the greater the loss.

Long belts are less liable to slip than short ones; for the latter are always stretched in a manner injurious to the journals and brasses, and, notwithstanding this amount of tension, they are still subject to a considerable loss in velocity.

I have undertaken some experiments in regard to losses of this nature, to which belts are liable, relatively to their lengths; and I have thought it well to prepare a table, for calculating the amount of motion transmitted by belts, which no operator can well do without.

Table showing the Slip of Leather Belts relatively to their Lengths.

Parallel belts. Length in metres.	Percentage of velocity lost by slipping.	Crossed belts. Length in metres.	Percentage of velocity lost by slipping.
2	4.2	2	3.5
4	3.9	4	3.2
6	3.6	6	2.9
8	3.3	8	2.6
10	3.0	10	2.3
12	2.7	12	2.0
14	2.5	14	1.8
16	2.3	16	1.6
18	2.1	18	1.4
20	1.9	20	1.2

When we wish to ascertain the loss in velocity of a belt, it is sufficient to *multiply the number of revolutions of the driving pulley by its diameter, and divide the product by the diameter of the driven pulley; the quotient is the velocity; then multiply the quotient by the number corresponding to the length of the transmitting belt, and deduct this product from the velocity already ascertained.*

1st Example.—A pulley, $0.^{m.}80$ in diameter, impressed with a velocity of 100 revolutions a minute, transmits motion, by means of a parallel belt 12 metres in length, to another $0.^{m.}30$ in diameter. What is the exact velocity of the latter?

$$\frac{100 \times 80}{30} = 266.66 \text{ revolutions.}$$

266.66×2.7 per cent. $= 7.20$ loss.

$266.66 - 7.20 = 259.46$, actual revolutions.

2d Example.—A pulley or drum of $0.^{m.}75$ diameter, impressed with a velocity of 50 revolutions a minute,

drives another pulley $0.^{m}40$ in diameter, by means of a crossed belt 6 metres long. What is the exact velocity of the second pulley?

$$\frac{50 \times 75}{40} = 93.75 \text{ revolutions.}$$

$$93.75 \times 2.9 = 2.72 \text{ loss.}$$

$$93.75 - 2.72 = 91.03 \text{ revolutions.}$$

Causes of the Destruction of Belts, and Means of Remedying it.

Belts, after having served for a certain length of time, and having withstood more or less tension, become greatly impaired by stretching and narrowing.

The width of the straps diminishes in proportion to the strain upon them. Experience shows that, on the first day a belt is used, it suffers an elongation of one per cent. This action continues to diminish till the third day, after which the belt works on without much change in its dimensions.

The causes producing loss of velocity in belts are as follows:—

1st. Badly oiled machinery;

2d. Obstructions in the journal boxes;

3d. Wheel gearing to much toothed;

4th. Bad quality of leather;

5th. Bad couplings and bad sewing;

6th. Oil spilt upon the pulleys.

When a belt slips, the difficulty is remedied by sprinkling the rubbing surface with a mixture of Spanish white and resin. If the belt is smeared with oil, fuller's earth is employed, which has the property of absorbing

greasy substances, and the rubbing side of the belt is then scraped with a wooden blade.

Very often a badly made knot in a coupling joint, will cause the belt to lose one or two per cent. of velocity.

New Methods of Sewing the Couplings of Belts.

To transmit and secure the motion to be imparted, the belts are sewed in such a manner as best to insure against their slipping; but, as they always tend to elongate, in order to obviate this difficulty, the ends are bound together by a leather thong. These thongs are generally of Hungarian leather, cut into thin and narrow strips, so as to be readily handled, as well as to avoid the necessity of punching the belt with large holes, which would greatly impair its strength.

The flaxen or hempen thread, intended for sewing belts and their couplings, ought to be of superior quality, and smeared with some pitchy substance, to prevent it from ravelling under the pressure and friction produced by the continual passage of the belt over the pulley.

M. Hunebelle, of Amiens, manufactures very durable belts, the couplings of which are made by means of Hungarian leather prepared in some peculiar manner. I have myself substituted animal substances for thread. I have had good results from eel-skins, and have also tried small catgut. My experience has been that the belt of a spinning frame, sewed with this material, may last two years without suffering any deterioration; and the cost of this article is not so great as to oblige us to reject its employment.

CHAPTER IV.

PULLEYS.

PULLEYS, as I have already stated when speaking of them, should be accurately centred and bored for their attachment to the main or any other shaft, to which they must be strongly fastened by means of steel screws or keys, so as to insure them from changing position.

A key is preferably used. When a pulley is to be fixed upon a shaft, a small groove or slot is made upon the latter at the place where the pulley is to be placed; the same thing is then done with the hole bored in the pulley, and the key driven between these grooves. By proceeding in this wise, we are sure of success; for, pulleys thus fastened are very firm and turn true.

In many spinning mills, wooden pulleys or drums are used to transmit motion to the machinery (Fig. 4, Pl. I). The construction of pulleys or drums of this nature is as costly as that of cast-iron ones, and they wear out sooner, at the same time that they occasion a considerable loss of power. At first, for a certain length of time, they seem to work well, but they soon become loaded with fatty matters, proceeding from the leather straps, and in a few days, are rendered slippery, develop heat, and thus quickly ruin the belts, while their action is also defective.

Shape of the Pulleys.

The pulleys of the machines or frames themselves are always of cast iron, and made in the same manner as the transmitting pulleys, from which they differ, however, in their crowns, which are convex, instead of being flat.

The pulleys best adapted to the machines, and which insure their motion without great loss of power, are those of which the surfaces of the crowns have a convexity of one-twelfth, that is to say, a rise of one-twelfth of their width (Fig. 5, Pl. I.).

In order to give the same direction to the motion of two pulleys, we connect them by a (so-called) parallel belt (Fig. 6, Pl. I.); and to make them revolve in opposite directions, the belts are merely crossed (Fig. 7, Pl. I.).

Measure of Velocity.

The measure of velocity is the distance, from a given point of the circumference, gone over in a unit of time. The unit of time generally employed is one minute.

To find the circumference of any pulley, *multiply its diameter by* 3.1416. Or, the diameter is to the circumference as 7 is to 22.

Calculation of Velocity.

In order to ascertain the velocity of a pulley, *multiply the number of revolutions, in a minute, of the driving pulley by its diameter, and divide the product by the diameter of the driven pulley; the quotient will be the number of revolutions made by the second pulley.*

EXAMPLE.—What is the velocity of a pulley $0.^{m}30$ in diameter, driven by another $0.^{m}85$ in diameter, making 100 revolutions a minute?

$$\frac{100 \times 85}{30} = 283.33 \text{ revolutions.}$$

When several sets of pulleys transmit motion from one shaft to several other shafts, *multiplg the driving pulleys by each other, do the same with those of derived motion; then divide the product of the driving pulleys by that of the driven, and multiply the quotient by the number of revolutions of the main shaft or pulley.*

EXAMPLE.—What will be the velocity of a small pulley $0.^{m}20$ in diameter, set in motion by a pulley $0.^{m}80$ in diameter, fixed upon a shaft with a second pulley, of which the diameter is $0.^{m}35$, and which receives its motion from a main pulley of a diameter of $0.^{m}75$, making 125 revolutions a minute?

The product of the driving pulleys $= 0.^{m}75 \times 0.^{m}80$ or $75 \times 80 = 6000$.

The product of the driven pulleys $= 35 \times 20 = 700$.

The quotient of these two products $= \frac{6000}{700} = 8.571$.

125 revolutions $\times 8.57 = 1071.25$ revolutions a minute.

When it is desirable to change the velocity of a machine, the pulleys receiving motion are changed; and, to ascertain the diameter required for the new pulley, *multiply the known velocity by the diameter of the present pulley, and divide this product by the number of revolutions it is desired to obtain by the new one.*

EXAMPLE.—A pulley, $0.^{m}25$ in diameter, is driven

with a velocity of 300 revolutions a minute, and we desire to replace it by another revolving only 250 turns in a minute. What diameter shall we give the new pulley?

$$\frac{25 \times 300}{250} = 30 \text{ centimetres for the required diameter.}$$

Sometimes, to impart motion to a machine situated at a distance from the transmission, we resort to what is called a binder or carrying pulley, which simply consists of a rectangular and horizontal cast-iron hanger (Fig. 8, Pl. II.). This hanger carries two small wooden drums with a convexity of one-twentieth the width of their crowns, resting by means of iron axles upon brasses, the whole made to slide upon an upright A A. These drums never should be less than 20 centimetres ($0.^{m}20$) in diameter, and the same may be said of the stretchers; a large diameter never does harm. This contrivance, which was first introduced by a foreman named Buignet, stretches the belt in every direction.

CHAPTER V.

Gearing.

Wheel gear is a necessary part of machinery, serving to regulate, by their concurrence, the different velocities required by the exigencies of a spinning mill.

A wheel, intended to drive other wheels, should be

secured to a shaft by means of a key or cotter, so that it may be changed without difficulty.

A wheel, of which the teeth or cogs are arranged around its circumference, and perpendicular to the crown, is called a spur wheel. The bevel wheel is that in which the teeth are set upon the side of the circle.

Teeth or cogs are generally made of cast iron, sometimes of wrought iron, copper, or wood; these latter are generally made use of for the larger wheels, on account of the little noise they make, and because they are less liable to break by shocks.

A wheel, serving to communicate motion from one wheel to another, is called the carrier, intermediate gear, and revolves upon a shaft which is fixed with a slide to a cast-iron support. It should be capable of turning in every direction we may desire. This support should be so arranged as to be, at pleasure, withdrawn more or less from the change pinion.

We designate by the name of pinion a small gearing intended to regulate the draught of the slivers of filamentous material.

Compound gear is that in which two or three wheels are united by a common shaft (Fig. 9, Pl. II.), and serves to impart either very great or very small velocity.

Two wheels, when in gear, always revolve in opposite directions (Fig. 10, Pl. II.). In order to give them the same direction, it is necessary to interpose another wheel, called the intermediate wheel (Fig. 11, Pl. II.), by which the motion is transmitted in the same direction.

EXAMPLES.—In a drawing frame, the fluted rollers charged with guiding the slivers of wool move in the same direction; while the pressure rollers (top rollers),

which are driven by this motion, revolve in an opposite direction.

Let us suppose that the drawing apparatus consists of two small rollers meant to revolve in the same direction; now we attach a driving wheel to the axle of the first roller, and a regulating pinion, intended to produce the draught, to the axle of the second. If they are thrown into gear in this manner, what will be the result? The rollers will turn in opposite directions, and the effect of drawing will not be produced; but, on the contrary, the slivers will be rolled round the cylinders. If, on the other hand, we interpose between them an intermediate wheel, moving upon its own axle, the desired effect will be produced, and the drawing will proceed.

Each tooth of a driving wheel always carries along one tooth of the driven wheel.

The gearings, intended to transmit motion from the motive power to the main shafts, are of great diameter, and with teeth strong enough to bear, without yielding, the strain of the entire motive power in use.

The velocity of wheels is determined by the same formula which gives the velocity of pulleys; if, at all events, the gearing is not compound.

Thus, *multiply the number of revolutions of the driving wheel by the number of teeth, and divide the product by the number of teeth of the driven pinion; the quotient will be the required velocity.*

Example.—A wheel having 100 teeth, and making 25 revolutions a minute, drives a pinion of 25 teeth, what will be the velocity of the latter?

$$\frac{100 \times 25}{25} = 100 \text{ revolutions a minute.}$$

Intermediate wheels are not regarded; but, if the driving wheel and the driven pinion are interposed in a compound gearing, the second formula for pulleys must be employed.

Multiply the driving wheels by each other, the driven wheels by each other, and divide the product of the drivers by that of the driven; then multiply the quotient by the number of revolutions of the first driving wheel.

EXAMPLE.—A wheel with 50 teeth, making 25 revolutions a minute, drives another wheel having 30 teeth on the same shaft with one having 45, thrown into gear with another with 20 teeth; what will be the number of revolutions made by the last named wheel?

$$\frac{50 \times 45}{30 \times 20} \times 25 = 93.75 \text{ revolutions.}$$

When we wish to ascertain the velocity transmitted from the driving-engine, we *multiply the number of strokes of the piston, or revolutions of the fly-wheel of the engine, by the number of cogs of the wheel attached to the shaft of the fly-wheel, and divide the product by the number of cogs of the transmitting pinion.*

EXAMPLE.—A steam-engine makes 45 strokes of the piston a minute, and carries a wheel having 225 cogs (or teeth) attached to the shaft of the fly-wheel, which drives a pinion having 101 teeth; what will be the velocity of the pinion?

$$\frac{45 \times 225}{101} = 100.25 \text{ revolutions.}$$

CHAPTER VI.

Of Friction.

The relation of pressure to friction depends entirely on the nature of the rubbing bodies, and of the lubricating substances employed. Friction increases in direct proportion to the pressure exercised upon the rubbing bodies, especially if they are at rest. The less the friction surfaces, the less the friction; and it is for this reason that wooden journals and journal boxes have been suppressed, and replaced by harder materials, such as hard brass or bronze.

Formerly, wooden journal boxes had a surface double that of composition ones. Unfortunately, most bronzes sold under that name are really but poor alloys. The best compositions of bronze for journal boxes are the following:—

Alloy for journal boxes of transmitting shafts.

Copper	88 parts.
Tin	12 "

Alloy for the brasses of drawing and spinning frames.

Copper	86 parts.
Tin	14 "

Alloy for steps, collars, &c.

Copper	84 parts.
Tin	16 "

The following table may be consulted in determining the loss of power caused by friction of the bearings, while in motion.

Table showing the Ratio of Friction to Pressure for Axles moving in Journal Boxes.

Nature of the rubbing surfaces.	State of the surfaces.	Ratio of the Friction to the Pressure. When the lubricating substance is not constantly furnished.	Ratio of the Friction to the Pressure. When the lubricating substance is constantly renewed.
		Coefficients.	
Iron journals upon bronze cushions	Smeared with olive oil, lard, tallow, or other unctuous substances.	0.075	0.054
Iron upon cast iron	id.	0.075	0.054
Cast iron upon bronze	id.	0.075	0.054
Cast iron upon cast iron	id.	0.075	0.054
Iron upon lignum vitæ	id.	0.125	0.054
Cast iron upon lignum vitæ	id.	0.100	0.092
Cast iron upon cast iron	id. and water	0.140	0.092

When we desire to ascertain the loss caused by the friction of shaft bearings on their brasses, we *multiply the real pressure or actual strain by the coefficient of friction, and multiply the result by the velocity per second of the journals; the product will express the loss of power in kilogrammetres; and, by dividing this number by 75, we have the power absorbed expressed in horse-power.*

Example.—An iron shaft weighs 80 kilogrammes, and is driven with a velocity of 130 revolutions a minute; it has a diameter of 8 centimetres ($0.^{m}08$), and turns on a

cast-iron surface oiled in the ordinary manner (not constantly). What will be the loss of power?

The coefficient of friction, in this case, is equal to 0.075; and therefore, for a pressure of 80 kilogrammes, the friction will be $0.075 \times 80 = 6$ kilogrammes.

The velocity per second being $\frac{0.^{m}08 \times 3.1416 \times 130}{60''} =$ 0.54 metre; the power absorbed by friction is 6 kilogrammes $\times 0.^{m}54 = 3.24$ kilogrammetres, $= \frac{3.24}{75} = 0.043$ or about $\frac{1}{24}$ of a horse-power.

Nature of Lubricating Substances.

As I mentioned in speaking of transmission, the oiling of the journal boxes is a matter of great importance in an economical point of view, as well as in regard to the regularity of motion in the machinery.

The oils employed in manufactures are numerous, especially of late. The distillation of coal has given us products mixed with vegetable and animal oils, &c., and sold under more or less scientific names which, often, have no relation to their nature.

For oiling, I reject all oils produced by the distillation of coal, as being too volatile and causing gumming. These mixed oils, when at rest, form different products, which separate according to their relative densities, that on the surface being too volatile.

The following substances may be employed for lubricating the journals or brasses.

For the gearing of the motive power.

Tallow	10 kilogrammes.
Olive oil	1 kilogramme.
Plumbago	50 grammes.

For shaft bearings.

Olive oil (not salad oil); it is dear but good.

For spindle steps.

Purified neat's foot oil and olive oil, equal parts.

CHAPTER VII.

The Motive Power.

Steam-engines are generally supplied with fly-wheels to regulate their motion.

The fly-wheel is not only intended to prevent irregularities of motion due to the fact that, in machinery, power and resistance are every moment varying, but also to accumulate the power in such a manner, that the entire apparatus may, periodically, overcome obstacles against which the engine alone would fail.

It must not be supposed from this explanation that the fly-wheel creates power; on the contrary, it occasions a loss of power by its own resistance which must be overcome. It only modifies the action of power, by momentarily producing a considerable effect. Generally speaking, *what is gained in power, is lost in time; and conversely.*

In order to work the motive power properly, before setting it in motion, we should loosen all the belts from the fast pulleys A, and slide them on to the loose pulleys B (Fig. 12, Pl. II.); without this precaution, the power of the engine would not be great enough to overcome the resistance of inertia.

One horse-power is equal to 75 kilogrammetres (see the tables at the end of the work), and is the unit of power employed in mechanics. By kilogrammetre is meant a weight of one kilogramme raised to the height of one metre in a second of time.

The estimate of the motive power is obtained by means of Prony's break (dynamometre), or that of M. Morin. This dynamometre is attached to the main shaft, and its extremity, terminating in a lever, is furnished with a scale pan to receive the weights which determine the power of the engine. The machine is made to move at the ordinary velocity. These details, moreover, will be found in M. Morin's *Aide Mémoire de Mécanique.*

CHAPTER VIII.

Levers.

A LEVER is an inflexible bar, every point of which may revolve around a fixed point called a fulcrum.

Every lever is acted upon by a power and a resistance, and the distance, from the point at which either is applied to the fulcrum, is called the arm of the lever.

We distinguish three classes of lever, depending upon the different positions of the power, the resistance, and the fulcrum.

1st. A lever is of the first class, when the fulcrum is between the power and the resistance.

2d. A lever is of the second class, when the fulcrum is at one extremity, the power at the other, and the resistance between.

3d. A lever is of the third class, when the fulcrum is at one extremity, the resistance at the other, and the power between.

Mules and preparatory machines are all furnished with levers in equilibrium with the pressure; they are destined to press the slivers of wool in course of preparation, in order to draw them out suitably. The levers employed in this case are of the third class.

When the power is to be determined, *divide the length of the arm, between the fulcrum and the resistance, by that of the arm between the fulcrum and the power, and multiply the quotient by the resistance.*

Example.—Given a power A (Fig. 13, Pl. II.) placed at 12 centimetres from the fulcrum B, and a resistance C of 20 kilogrammes placed at 48 centimetres from the fulcrum. What will be the amount of force in kilogrammes?

$$\frac{48}{12} \times 20 = 80 \text{ kilogrammes} = \text{power A}.$$

The same result is obtained by multiplying the resistance by its arm of the lever, and dividing the product by the distance from the fulcrum to the power.

If we wish to diminish the pressure of any of the pre-

paratory machines, admitting that this last lever is applicable, *we multiply the new power we desire to apply by the length of the arm, between the resistance and the fulcrum, and divide the product by the original power.*

EXAMPLE.—Desiring to apply a pressure of 75 kilogrammes, instead of one of 80 kilogrammes, which was at first used, the resistance being $0.^{m}48$ from the fulcrum, we wish to ascertain at what distance we must place the resistance?

$$\frac{75 \times 0.^{m}48}{80} = 0.^{m}45 \text{ or } 45 \text{ centimetres.}$$

These calculations are applicable to all the different machines used in spinning. I shall give, in the article on preparing and spinning wool, a table indicating the pressures, with designation of weights or powers, calculated from the lengths of the arms of levers and the resistances.

For practical use, I cannot too much recommend the *Guide de Mécanique Pratique*, by Armengaud, Jr. This valuable work will be of great service in making computations.

The following table has been prepared so as to show the relation between numbers and their powers, roots and circumferences, and is of daily use to manufacturers and operators.

Table of Numbers, showing their Squares and Square Roots, Cubes and Cube Roots; and also the Circumferences and Areas of Circles of the same numbers considered as Diameters.

Numbers or diameters.	Squares.	Square roots.	Cubes.	Cube roots.	Circum-ferences.	Areas.
1	1	1.00	1	1.00	3.14	0.7854
2	4	1.41	8	1.26	6.28	3.1416
3	9	1.73	27	1.44	9.42	7.06
4	16	2.00	64	1.59	12.56	12.56
5	25	2.23	125	1.71	15.71	19.63
6	36	2.45	216	1.82	18.85	28.27
7	49	2.64	343	1.91	21.99	38.48
8	64	2.83	512	2.00	25.13	50.26
9	81	3.00	729	2.08	28.27	63.61
10	100	3.16	1,000	2.15	31.41	78.54
11	121	3.31	1,331	2.22	34.55	95.03
12	144	3.46	1,728	2.29	37.70	113.09
13	169	3.60	2,197	2.35	40.84	132.73
14	196	3.74	2,744	2.41	43.98	153.94
15	225	3.87	3,375	2.46	47.12	176.71
16	256	4.00	4,096	2.52	50.24	201.06
17	289	4.12	4,913	2.57	53.40	226.98
18	324	4.24	5,832	2.62	56.55	254.47
19	361	4.36	6,859	2.67	59.69	283.53
20	400	4.47	8,000	2.71	62.83	314.16
21	441	4.58	9,261	2.76	65.97	346.36
22	484	4.69	10,648	2.80	69.11	380.13
23	529	4.79	12,167	2.84	72.25	415.47
24	576	4.90	13,824	2.88	75.40	452.39
25	625	5.00	15,625	2.92	78.54	490.87
26	676	5.10	17,576	2.96	81.68	530.93
27	729	5.19	19,683	3.00	84.82	572.55
28	784	5.29	21,952	3.04	87.96	615.75
29	841	5.38	24,389	3.07	91.10	660.52
30	900	5.48	27,000	3.11	94.25	706.86
31	961	5.57	29,791	3.14	97.39	754.77
32	1,024	5.65	32,768	3.17	100.53	804.25
33	1,089	5.74	35,937	3.21	103.67	855.30
34	1,156	5.83	39,304	3.24	106.81	907.92
35	1,225	5.91	42,875	3.27	109.95	962.11
36	1,296	6.00	46,656	3.30	113.09	1,017.87
37	1,369	6.08	50,653	3.33	116.24	1,075.21
38	1,444	6.16	54,872	3.36	119.38	1,134.11

Numbers or diameters.	Squares.	Square roots.	Cubes.	Cube roots.	Circumferences.	Areas.
39	1,521	6.24	59,319	3.39	122.52	1,194.59
40	1,600	6.32	64,000	3.42	125.66	1,256.64
41	1,681	6.40	68,921	3.45	128.80	1,320.25
42	1,764	6.48	74,088	3.48	131.94	1,385.44
43	1,849	6.56	79,507	3.50	135.09	1,452.20
44	1,936	6.63	85,184	3.53	138.23	1,520.53
45	2,025	6.71	91,125	3.56	141.37	1,590.43
46	2,116	6.78	97,336	3.58	144.51	1,661.90
47	2,209	6.85	103,823	3.61	147.65	1,734.95
48	2,304	6.93	110,592	3.63	150.79	1,809.56
49	2,401	7.00	117,649	3.66	153.93	1,885.74
50	2,500	7.07	125,000	3.68	157.08	1,963.50
51	2,601	7.14	132,651	3.71	160.22	2,042.82
52	2,704	7.21	140,608	3.73	163.36	2,123.72
53	2,809	7.28	148,877	3.75	166.50	2,206.19
54	2,916	7.35	157,464	3.78	169.64	2,290.22
55	3,025	7.42	166,375	3.80	172.78	2,375.83
56	3,136	7.48	175,616	3.83	175.93	2,463.01
57	3,249	7.55	185,193	3.85	179.07	2,551.76
58	3,364	7.61	195,112	3.87	182.21	2,642.08
59	3,481	7.68	205,379	3.89	185.35	2,733.97
60	3,600	7.74	216,000	3.91	188.49	2,827.44
61	3,721	7.81	226,981	3.94	191.63	2,922.47
62	3,844	7.87	238,328	3.96	194.77	3,019.07
63	3,969	7.94	250,047	3.98	197.92	3,117.25
64	4,096	8.00	262,144	4.00	201.06	3,216.99
65	4,225	8.06	274,625	4.02	204.20	3,318.31
66	4,356	8.12	287,496	4.04	207.34	3,421.19
67	4,489	8.18	300,763	4.06	210.48	3,525.66
68	4,624	8.24	314,432	4.08	213.63	3,631.69
69	4,761	8.30	328,509	4.10	216.77	3,739.29
70	4,900	8.36	343,000	4.12	219.91	3,848.46
71	5,041	8.42	357,911	4.14	223.05	3,959.20
72	5,184	8.48	373,248	4.16	226.19	4,071.51
73	5,329	8.54	389,017	4.18	229.33	4,180.39
74	5,476	8.60	405,224	4.20	232.47	4,300.85
75	5,625	8.66	421,875	4.22	235.62	4,417.87
76	5,776	8.72	438,976	4.23	238.76	4,536.46
77	5,929	8.77	456,533	4.25	241.90	4,656.63
78	6,084	8.83	474,552	4.27	245.04	4,778.37
79	6,241	8.89	493,039	4.29	248.18	4,901.67
80	6,400	8.94	512,000	4.31	251.32	5,026.55
81	6,561	9.00	531,441	4.32	254.47	5,153.01

Numbers or diameters.	Squares.	Square roots.	Cubes.	Cube roots.	Circumferences.	Areas.
82	6,724	9.05	551,368	4.34	257.62	5,281.02
83	6,889	9.11	571,787	4.36	260.75	5,410.60
84	7,056	9.16	592,704	4.38	263.89	5,541.78
85	7,225	9 22	614,125	4.39	267.03	5,674.50
86	7,396	9.27	636,056	4.41	270.17	5,808.81
87	7,569	9.33	658,503	4.43	273.32	5,944.68
88	7,744	9.38	681,472	4.45	276.46	6,082.12
89	7,921	9.43	704,969	4.46	279.60	6,221.14
90	8,100	9.48	729,000	4.48	282.74	6,361.74
91	8,281	9.54	753,571	4.50	285.88	6,503.89
92	8,464	9.59	778,688	4.51	289.02	6,647.62
93	8,649	9.64	804,357	4.53	292.17	6,792.92
94	8,836	9.69	830,584	4.54	295.31	6,939.79
95	9,025	9.74	857,375	4.56	298.45	7,088.23
96	9,216	9.80	884,736	4.58	301.59	7,238.24
97	9,409	9.85	912,673	4.59	304.73	7,389.83
98	9,604	9.90	941,192	4.61	307.87	7,542.98
99	9,801	9.95	970,299	4 62	311.02	7,697.69
100	10,000	10.00	1,000,000	4.64	314.16	7,853.98

PART II.

CHAPTER I.

MANUFACTURE.

AFTER having cast a hasty glance at the mechanical and constituent elements of every spinning mill, and having briefly considered the laws by which they are governed, it is necessary to come to the more important and difficult part of this manufacture, so diversified in its details. Long experience, numerous researches, special studies, accurate and practical, have enabled us fully to treat this subject in all its branches.

As will be observed, we have dwelt at length upon the subject of sorting and manipulating the wool, which are operations forming the basis of the subsequent ones. This matter is one which, in every respect, deserves to engage the serious attention of manufacturers, and one which, I believe, has been, up to this time, too much overlooked by writers upon wool spinning.

Before going further, it will be best to say a few words in regard to wools in general.

Wool, strictly speaking, is a cutaneous secretion taking place through the epidermic pores of the animal. These pores are all of the same diameter, and arranged at equal

intervals upon the epidermis of the same sheep. They vary according to species, and are narrow, straight, or tortuous. They stand toward the wool in much the same relation that a drawing plate does to the metal to be drawn out; and, consequently, the wool fibres will be fine, smooth, or undulating, according to the particular shape of the pores by which they are thus gauged.

M. Raspail has published a very interesting work on the microscopic structure of wool, and has found that the long hairs planted in the hide of wool-bearing animals, the aggregation of which constitutes wool, are tubes filled with an oily and granulated liquid. They are terminated at their apex by a cone, and at their root by a bulb bristling with fibrillæ (Fig. 14, Pl. II.). Their diameter varies from a twentieth to a sixty-fifth of a millimetre.

Chemical analysis gives:—

Carbon	50.69
Hydrogen	3.94
Oxygen	34.04
Nitrogen	11.33
	100.00

Wool, if kept in a well-ventilated place, undergoes very little change. The best way of preserving it, is to shut it up in a large whitewashed chamber, in which, every now and then, it is well to burn a little sulphur, in order, among other things, to destroy moths and other vermin likely to injure the material. Under the influence of heat, wool decomposes, giving carbonate of ammonia and much oil. Acids act but feebly upon it;

caustic alkalies and their solutions, on the other hand, dissolve it entirely.

The reader will find, further on, enumerated the distinctive characters of different wools, according to their source, and the breed of sheep from whence derived.

We will not close this brief consideration of the subject, without adverting to the enormous sum to which the consumption of our mills amounts. The annual cost, in France, is at least one hundred and ninty-six millions of francs ($39,000,000). The foreign market scarcely furnishes thirty-four millions worth. These sums are, of themselves, more eloquent than anything we could add; and thanks, on the one hand, to the comforts and luxuries which are pervading all classes of society, and, on the other, to the constant improvement of breeds, it is not to be doubted that our consumption of wool will go on increasing, while the amount of imported material will diminish.

Again, although our intention is to confine ourselves to the subject of wool spinning, we think it will be interesting to manufacturers, to supply them with the nomenclature of textile materials, employed in the manufacture of tissues of every character and description.

These materials require different treatment, in order to convert them into thread or yarn, according to their individual nature, or to the uses for which they are destined. On the following page will be found a table of textile materials divided into three great classes.

The first class embraces aggregated materials, that is to say, those the threads of which are formed by agglomeration and torsion. They are obtained by massing together the filaments constituting the material, and, by

means of torsion, producing continuous threads. Wool and cotton enter into this class.

The second class embraces materials obtained by subdivision. These materials, which are found in great abundance, have to be reduced to their woody fibres by means of mechanical processes, and these fibres are then converted into thread by means of twisting, or by simple subdivision of the mass. Hemp and flax are examples of this class.

The third class is subdivided into two groups:—

1st. Materials susceptible of being drawn out into filaments or wires, such as glass and the metals.

2d. Natural products requiring neither subdivision, torsion, nor agglomeration, to convert them into threads (filaments). Such are hair, reeds, &c.

Table of Textile Materials.

First Class.	Second Class.	Third Class.	
Threads formed by agglomeration and torsion.	Threads formed by division and torsion.	1st Group. Formed by drawing out.	2d Group. Natural.
Cotton	Abaca	Silver	Hair
Cashmere	Wood	Aluminium	Canes
Animal wool	Asbestos	Cadmium	Reeds
Pine floss	Hemp	Copper	Straw
Fur	Fibres of leaves	Tin	Rushes
Bombyx silk	Flax	Iron	
	Ma or Chinese nettle	Nickel	
	Straw	Gold	
	Phormium tenax	Platinum	
	Cactus or vegetable silk	Lead	
	Agave	Palladium	
	Whalebone	Zinc	
	Esparto		
	India-rubber		
	Gutta-percha		

CHAPTER II.

Sorting the Wool.

Sorting is, without doubt, one of the most essential operations of wool spinning; for, without it, we cannot produce the different qualities of yarn required for the uses of industrial arts. It consists in separating the different qualities of wool produced by the varieties of wool bearing animals. These qualities must succeed each other gradually, either in fineness or in length.

Of Wool Bearing Animals.

The qualities of wool, produced by animals of the same breed, often vary from one pasture to another; the difference, in this respect, is so great, that the price of wool in one locality will frequently be much higher than that of sheep pasturing in an adjoining field. This remarkable fact, however, is readily accounted for. Every one is aware of the fondness of sheep for salt pastures; and accordingly, those raised in such locations, generally produce strong white wool; whereas those inhabiting marshy and barren districts, suffer from their state of pauperism, and, being less nourished, furnish wools of an inferior quality. The juiceless herbs of such soils are insufficient for their development, and they remain, without improving, in their primitive condition.

The question of pastures then is one of great importance, and should be considered by the woollen-spinner, not only because it is well for him to recognize the breed of animals furnishing the wool he buys, but because it is also necessary that he should know its source.

Improvement of Sheep.

This great question is the order of the day, and is in the hands of practical men who, we hope, will arrive at a happy result. By care and judicious crossings, we may rest assured that the breed can be improved. M. Ellmann's experiments support this assertion. There is in England a tract of land called the South-Downs, which, formerly, possessed a breed of sheep running at will among sandy and uncultivated hills. The fleece and horns of these sheep were black. They were small, and far from well-shaped, with long and thin necks, high in the shoulder and short behind, tall in the loins, low in the rump, with sharp backs, flat sides, and narrow fore-quarters. Their legs were good, but formed of large bones.

Mr. Ellmann, of Glynde, near Lewes, in 1780, undertook to convert this uncouth breed into one of first class merits; and through the most careful attention, and constant perseverance during fifty years, he brought his flock to a high order of excellence. The steady increase in the market value of this breed was a natural consequence of their continued improvement, so that, even during the first few years of his labors, M. Ellmann's sheep increased fifty per cent. in price.

In form and characteristics, the South-Downs are now almost entirely changed. They are smaller boned,

although equally solid; and, having a great aptitude for fattening, they have become heavy bodied; so that their quarters, instead of weighing as formerly five or six kilogrammes, now often weigh eighteen to twenty-two kilogrammes; while the weight of their fleeces has also nearly doubled, and their wool is finer than any other long-stapled wool supplied by England.

The skilful hand of the breeder then has eradicated from the South-Down sheep every trace of their original peculiarities, improved their meat, and lastly, brought their color from black to the most brilliant white.

The transformation is complete; and it is desirable that our French breeders should imitate the English, who, with a soil much less favorable than our own, are still greatly our masters in agriculture. It should, however, be stated that this important branch of zootechny is making rapid progress in this country.

Varieties of Breeds.

Wool bearing animals are distinguished from each other according to the quality and weight of their wool.

Short, fine, and undulating wools are produced:—

1st. By the Merino sheep. This breed was imported by the Romans from Africa, and afterwards, from them by the Spaniards.

2d. By indigenous breeds crossed with Merinos, called metis or half-breeds. These sheep weigh from sixteen to twenty-four kilogrammes; and their wool, after being fleece-washed, weighs from eight hundred grammes to a kilogramme and a half.

The pure Merino sheep has a well-developed body,

covered with fine, close, strong, and curly wool. The ram has thickly fleeced cheeks and a heavy neck, from which depends a very woolly dewlap. Their fleeces are very rich. The ewe resembles the male, except that she is of lighter build, and has no horns. The color of the wool is a rather dirty gray-white, which, however, becomes very white after washing. These sheep are more delicate than the indigenous breeds.

The small native breeds are those of the Ardennes, of Berry, of Sologne, and of the South of France. These sheep weigh from fifteen to twenty kilogrammes, and their fleece, in grease, from one to two kilogrammes. They produce a shorter stapled wool than the purer breeds.

The large native breeds are those of Normandy, Picardy, Flanders, and the North. These sheep are very heavy, weighing from thirty to fifty kilogrammes, and their fleece from two to five kilogrammes. The wool is long and excellent for combing. These breeds are better adapted than the small ones for crossing with the English long-woolled sheep, whose weight often reaches sixty kilogrammes, that of their fleeces from four to six kilogrammes.

The varieties of sheep are divided into lowland and highland breeds.

The lowland are of large size, and produce coarse wool. Under this head, we class Hungarian sheep, and those of Dishley, Lincolnshire, Daartmoor, &c.

The highland or mountain breeds are those of Padua, the Merinos, &c.

Character of Wool from Different Sources.

Wool is classified and valued by the length of its staple, and the diameter of its fibre, its suppleness, elasticity, and strength.

The fineness of wool is determined by the number of undulations in a given length of the staple. A very wavy staple should double its length by stretching, and then return to its original dimensions.

The merino breed have their finest wool on the shoulders, flanks, and rump; and their worst on the head, legs, and belly.

There are two principal sorts of wool, namely: short or carding wool, much waved and used for the manufacture of cloth; and long or combing wool, used for making light stuffs.

These two sorts give rise to four very distinct classes:—

1st. Fleece wool for combing;

2d. Fleece wool for carding;

3d. Pulled wool (mortling) for combing;

4th. Pulled wool (mortling) for carding.

We mean by fleece wool, all that is shorn from the living animal; and by pulled wool (pelt wool, mortling), that pulled from the skin of the animal after death. The latter is less valuable than the former; partly because it is damaged, and partly because it seldom has attained the full growth and development, which is necessary to its strength.

These two sorts of wool differ in their stoutness and softness. Both are generally white, though sometimes black, or brown. These latter colors are set aside to be worked separately.

The skins supplying pulled wool are of two classes:
1st the skins of animals killed on farms;
2d the skins of animals killed in slaughter houses.

According to its degree of fineness, pulled wool is sorted into fine, medium, and common; and is received either in sorted locks or in the whole fleece. This kind of wool, never having reached maturity, and, moreover, being weakened and impaired by the lime used in stripping the skin, is lighter and weaker than fleece wool.

Character of Wool from Different Sources. Cleanness, Quality.

The varieties of sheep, in different counties, produce good or bad qualities of wool very much in accordance with the character of the inhabitants.

Thus Spain, which, formerly, at the height of her power, furnished Europe with the best wools in the world, has at the present day sunk to a third-rate producer, supplying us only with wools inferior to our own. Indifference, which is the defect of Spanish character, has greatly contributed to the extinction of thousands of the flocks which, formerly, were pastured in that fertile country.

Saxony and Silesia, on the other hand, have progressed by improving the merino breed, which is of Spanish origin, and now produce the finest wools in the market, more valuable, indeed, and finer than our own.

The English colony of Australia produces wools superior in beauty to ours, though not so fine as those of Saxony and Silesia.

France, however, possesses fine flocks. Our wools are

generally esteemed; those of Champagne, Brie, and Beauce rank first, and are followed by those of Artois, Normandy, Picardy, and the north. Native wools of the South of France are not always well dressed.

Russia furnishes several varieties of wool. Those of Poland and Silesia are very fine; but, on the other hand, there is a kind produced resembling goat's hair, and this sort is of considerable weight.

The once flourishing Roman colony of Algeria was covered with the numerous flocks of sheep, raised there by the Romans for the supply of their armies. This breed they imported into Europe, and, after improving it, introduced it into Spain, whence, in turn, we have derived our merino breed. Since Algeria has passed from the Roman sway, the breed has become impoverished, and fallen back to its primitive condition. The wools we receive from those countries are fair enough in quality, but full of sand and burs. They are heavy and somewhat dry, yet not much matted when properly scoured. The provinces of Algeria which furnish most wool are: 1st, that of Constantine, of which the wool is fine enough, but full of burs; 2d, the province of Oran, supplying coarser and less thistly wools than the preceding, but at the same time, sandier and dryer. Tlemcem and Mostaganem, in the province of Oran, afford quite good and strong wool. All the foregoing wools are heavy.

Morocco wools are about similar to those of Algeria, but less esteemed as having less strength, and being dry, shanked,* and somewhat fleece bound.

* We call shanked wool a staple which is not wavy, but is straight like hair.

Turkey is not in advance of Morocco in the production of wool. The traditional indolence and indifference of the Turks are the principal causes of this inferiority. The wools of these countries are of poor quality, weak, matted, and containing burs of an enormous size.

There are several localities in America which produce wool. Buenos Ayres does the largest business in this line, and supplies very fine wools which, however, are full of burs, and are received by us in grease.

England supplies very clean and strong, but rather coarse wools. Her Australian colonies furnish her with finer materials.

Holland sends us wools of about the same character as the English.

The different qualities of wool differ so much, not only in kind, but from year to year, that it sometimes becomes difficult to determine their exact value. They are rendered the more deceitful by the grease with which they are covered, and which makes them unctuous to the touch.

It will always be easy to recognize the difference existing between the wool of well conditioned, and that of the badly nourished sheep. That of the latter appears dry, has shank locks and is somewhat fleece bound, the extremity of the staple being often coarser than the roots, and the fleece weighing less than that of other kinds.

Wool is generally sold washed, either fleece or tub washed. It is better to procure that which is fleece washed. All the wools of Africa, Turkey, and a part of those of France, are sold unwashed.

Badly-washed wool will be easily recognized by the touch; if it is ill washed, it will be sticky, and the

meshes adhering to each other, which is good evidence of the presence of undissolved natural grease.

It is well to be able to verify the fact, that a given sample of wool is more or less charged with grease, so as to settle its value, and estimate, at a glance, about the amount of loss it will suffer, as well as what it will be likely to yield both in quality and quantity. We should however say, that these points cannot be properly settled from an examination of any one fleece, because fleeces differ so greatly from each other, that we must draw our conclusions from the aggregate. The hints we have given will be of value to buyers, by leading them to a more thorough examination.

Sorting, or Separation into Qualities.

Before sorting according to the part of the animal from which the wool is taken, we separate the white, the black, the fine, the coarse, the hard, the matted, the shank locks, and the fleece bound, which are arranged in heaps.

To conduct this sorting, we should be provided with the necessary implements, which are: two trussels, upon which is placed a hurdle or screen to receive the fleeces; a pair of shears for cutting off the skins and the marks; baskets for containing the different sorts, as many as there are qualities; and, finally, scales to weigh them when filled.

The fleece, if it has not been pulled off, represents the form of the sheep. The first thing done is to cut off the dirty edges and the poorest parts, which are arranged according to quality. These low qualities form a distinct class, and the higher ones another.

Low Qualities.

1st	quality,	embracing	the lower belly and forehead.
2d	"	"	the lowest parts of the thighs.
3d	"	"	breech locks.
4th	"	"	tarry marks (marks put on the animals).

As soon as the borders are cut off, the fleece is separated through the middle into two portions, and then the fine part near the ear is removed. From this portion is obtained superfine wool, if there is any, which is divided into two qualities. After this, the shoulder is stripped, which gives a semi-fine, and the flank, which gives medium wool. That of the upper thigh is placed with the coarse, and that of the lower with the very coarse. Care must be taken to separate any wool mixed with straw, and any having tarry marks, which kinds form distinct qualities, having their own denomination.

The wool is generally picked or opened in sorting, so as to facilitate scouring, beating, and other subsequent operations.

High Qualities.

Wools, from the best portions of the fleece, are generally classified according to their fineness, as follows:—

No. 1.	Superfine . . .	from near the ear.
2.	Fine	" near the ear.
3.	Semi-fine . . .	" the shoulder.
4.	Medium . . .	" the flanks.
5.	Coarse . . .	" the upper thigh.
6.	Very coarse . .	" the lower thigh.

What has been said in relation to sorting, is applicable to the wools of Picardy, Normandy, and the North, coming from the large native breeds. We must add that, in sorting Merino or Spanish wools, the shoulder is not considered so fine as the flank.

Cost and Loss in Sorting.

In sorting the different qualities of a fleece, there is a loss from "evaporation," which varies according to the cleanness of the material, being very great when the wool is short, dry, and bound, and, especially, when it is pulled and in locks. The matters lost in sorting are dust, broken filaments, fribs, and other impurities. This loss varies, for washed wool, from two to five per cent.; and for the unwashed, from five to fifteen per cent.; but from these wastings can be withdrawn small bits of stuff (fribs), that may still be of some value.

Wools in grease should not remain too long without washing, for they turn yellow, and deteriorate. The wool which has on it the marks intended to designate the sheep of particular flocks, and which has been separated from the fleece, is subjected to the operation of cutting, and this wool is thus freed from a body, which prevented it from being converted into yarn.

The fleeces of hard or felted wool should be submitted to an operation, which consists in separating the filaments at their roots. Felted, matted, or bound wool results from a diseased condition of the sheep.

Dry, shanked, and fleece-bound wools should be rejected for combing purposes (worsteds). They are difficult of management by machinery, at the same time that they occasion great waste, and produce poor yarn. When

we look at the loss they undergo, in comparison with ordinary good wools, we certainly ought not to make an effort to obtain them, as some manufacturers do, simply on account of their low price. The yarn produced from such wool is no cheaper in its cost of preparation, and, at the same time, is always sold at a disadvantage.

Product, in the Sorting of Wools from the Principal Sources.

As I have already said, the quality of wool, both in coarseness and strength, differs from one year to another. A skilful sorter ought always to open the wool, and pick out all hard and foreign bodies, which he may find, in order to facilitate the operation of beating, and other subsequent ones. It is also, in every way, for the interest of a manufacturer to produce as many qualities as possible.

1000 kilogrammes of Picardy wool have given by sorting:—

1. Superfine . . .	30	kilogrammes
2. Fine	100	"
3. Semi-fine . . .	400	"
4. Medium . . .	300	"
5. Coarse . . .	100	"
1st quality fribs . .	5	"
2d " " . .	10	"
Breech locks . . .	5	"
Straw mixed . . .	30	"
Total . .	980	kilogrammes.

Loss.—20 kilogrammes by evaporation, cords, &c.

100 kilogrammes of Normandy wool gave:—

Washed.	1. Superfine	3 Kilog.	500	grammes.
	2. Fine	12 "	"	"
	3. Semi-fine	42 "	"	"
	4. Medium	28 "	"	"
	5. Coarse	8 "	200	"
	1st quality fribs	0 "	400	"
	2d " "	0 "	800	"
	Breech locks	0 "	400	"
	Straw mixed	3 "	"	"
	Total	98 "	300	

or 1.700 kilogrammes loss by evaporation and cords.

100 kilogrammes Tlemcem wool (Algeria), gave by sorting:—

Washed.	1. Superfine . .	1	kilogramme.
	2. Fine . . .	8	"
	3. Semi-fine . .	35	"
	4. Medium . .	30	"
	5. Coarse . .	12	"
	6. Very coarse. .	6	"
	1st quality fribs . .	1	"
	2d " " . .	2	"
	Total . .	95	"

Loss—5 kilogrammes in burs, sand, &c.

100 kilogrammes of Mostaganem wool (in grease) have produced:—

Qualities.	Weights.	Loss by washing and scouring.	100 parts of wool in grease have produced in combed, scoured wool,
1. Superfine . .	10 kilog. 300 grm.	60 per cent.	38
2. Fine . .	13 " 300 "	58 "	40
3. Semi-fine . .	23 " 700 "	54 "	44
4. Medium . .	22 " 700 "	50 "	47
5. Coarse . .	20 " 000 "	48 "	49
6. Very coarse .	4 " 000 "	46 "	50
Fribs . .	3 " 500 "	70 "	
	97 kilog. 500 grm.		

In England, sorting is conducted as follows: The wool is sorted first by qualities; the qualities are then sorted by numbers according to length, and not, as in France, according to fineness.

The better to show the numbers which may be spun with wool from different sources, and the coarseness of the qualities, we have prepared the following table:—

Comparison of Wools of different sources with their Diameter, and the corresponding Number of Yarns.

Sorting number.	Wool from Silesia.	Wool from Saxony.	Wool from Australia.	Wool from Champagne.	Wool from Spain.	Wool from North of France.	Wool from Algeria.	Number of yarn.	Diameter of the filaments. The unit is the millimetre.
1	Extra fine							225	From 0.015
2	Superfine	Extra fine						180	
3	Fine	Superfine	Extra fine					160	to
4	Semi-fine	Fine	Superfine	Extra fine				145	
5	Medium	Semi-fine	Fine	Superfine	Extra fine			130	0.025
6	Coarse	Medium	Semi-fine	Fine	Superfine			120	From 0.025
7	Very coarse	Coarse	Medium	Semi-fine	Fine			105	
8		Very coarse	Coarse	Medium	Semi-fine	Extra fine		95	to
9			Very coarse	Coarse	Medium	Superfine		85	
10				Very coarse	Coarse	Fine	Extra fine	70	0.045
11					Very coarse	Semi-fine	Superfine	55	From 0.045
12						Medium	Fine	30	
13						Coarse	Semi-fine	25	
14						Very coarse	Medium	20	to
15							Coarse	15	
16							Very coarse	10	0.075

CHAPTER III.

Beating.

After being sorted, the wool is not sufficiently cleansed to be directly submitted to the operation of scouring, and is, therefore, first beaten.

Beating is not alone intended to eliminate dust and other impurities which may be contained in wool, but, at the same time, to dispose the staple to open, and thus render the material softer and less resisting, when washed and worked over in the various machines.

In order to be well beaten, the staples of the wool should be free from natural grease, dry, and somewhat open; the dryer, the more readily beaten. If we unfortunately have the wool in a damp place, and then undertake to beat it, we shall encounter many difficulties. The various impurities, instead of escaping, will become fixed in a manner highly prejudicial to the operation of scouring, and the cleanliness of the yarn, while the wool will remain unopened, stringy, and will become felted during the operation of scouring.*

The wool to be beaten is either made into bales, or heaped up in a well-ventilated place, in order that it may absorb no moisture; and in this condition we may

* We call steeping or washing, the operation of washing wool in water only; and scouring, the operation of washing wool in water with soap or alkali.—*Trans.*

safely send it to be beaten. If the beating process is well carried out, the wool will be quite entirely free from the impurities which rendered it unfit for working. Well-beaten wool trebles, and even quadruples its former volume, when sufficiently opened.

Beating is accomplished more or less easily, according to the particular nature of the wool, and the extent to which it has been freed from natural grease. Among the wools which particularly need beating, are the hard knotty kinds; but, in cases where they present too much resistance, we are obliged to resort to a picking process by hand or machinery.

Fleece-bound wools are not more readily beaten than the preceding; and, when they resist beating, they have to be opened by hand. This operation is an expensive one, and greatly increases the cost of preparing them.

Hard and fleece-bound wools, pulled wool charged with lime, and coarse wools are beaten by machinery. A machine beater, with movable rods, appears to us the most suitable, for no wool, however full of impurities, can resist its action. (See Fig. 15, Pl. III.)

This beater consists of a wooden frame *A*, upon which moves a sieve or screen bottomed car *B* filled with wool. At the lower part of this stand are arranged pedestals supporting an iron shaft *C*, furnished with three excentrics *D*. Each eccentric, when worked, gives an oscillating motion to a movable frame *E*, by means of iron rods *F* (Fig. 16). The movable frame carries at its upper part a cylinder *G*, supplied with rods *H*. This cylinder obeys the tension of the belts *I*, which is greater or less, according to the greater or less distance of the movable frame from the eccentric *D*. When distant, the belts *I*

are stretched and throw back the rods to the opposite side; and when near the eccentric, the belts *J* become stretched, and the rods beat upon the wool. The shaft *C* is furnished at one end with pulleys, and at its other extremity with a fly wheel, which serves to overcome resistance. A small pulley *L* transmits motion to the car *B* supplied with a rack.

In order to use this beater, the wool is spread upon the car *B* to a depth of about ten or twelve centimetres, and the machine is set in motion. There are never less than three rods beating the wool at one time, and, after a few strokes, the material is seen to open. After the car has made two trips, the wool is turned, care being taken not to allow the rods to beat on the empty car. Six or eight strokes generally suffice for the least, and ten or twelve for the most impure wools. The time occupied by the car in each transit, varies from two to three minutes. The weight of wool, which a beater can bear, is four or five kilogrammes.

During the twelve hours' work, a hundred and twenty to a hundred and sixty kilogrammes of the cleanest wools can be beaten on a machine thus constructed, and two machines can be generally tended by one workman.

For extra fine wools, machine beating is not proper, as it acts with too much violence. In this case hand beating is to be preferred.

Hand beating is managed as follows: An open wicker screen is placed upon trussels, and over it two men spread the wool to be beaten, amounting to one and a half to two kilogrammes. Each man then takes two rods 1.10 metre long, with which they beat rapidly on the wool, taking care to draw them back horizontally, so as not to throw

up the material, which they also occasionally turn, in order to allow all its parts to be exposed to the beating.

Beating is stopped when the wool seems well cleared of most of its impurities, the operation continuing however, if evidence is still given of their presence, but not carried too far; as in that case, the wool would inevitably become felted.

During the beating, and by the action of the rods, the impurities pass through the sieve; a part is blown away as dust, and is considered lost. The impurities which are received upon a cloth placed under the sieve, consist of sand, straw, and fribs. These fribs are collected and beaten separately in a machine called a Helicoïdal beater. Nothing should ever be lost, not even the refuse of this last operation, which finds its use in agriculture, as manure.

Cost of Beating.

To drive all the beating machinery of a mill using twenty horse-power, we require three horse-power, one man's labor, and have sundry other expenses. The work performed in twelve hours by two beaters amounts to:—

340	kilog.	of wool	for yarns	No.	80	to	100.
330	"	"	"	"	60	"	80.
320	"	"	"	"	40	"	60.
300	"	"	"	"	20	"	40.
280	"	"	"	"	10	"	20.
220	"	from upper thighs.					
190	"	Fribs.					
190	"	Straw mixed.					

The loss in material, from beating, is proportionate to the amount of impurities in the wool. There are wools so charged with them, that they lose, in beating, ten per cent. of their weight.

Those in which the loss is the greatest, are pulled wools, and those of Algiers; these last named contain much sand.

Waste in Wools from Different Sources.

Wool from Picardy and Normandy.	Weight of sorted wool.	Weight of beaten wool.	Fribs.	Waste.
1. Superfine .	100 kilog.	96.0 kilog.	2.4 kilog.	1.6 kilog.
2. Fine .	100 "	96.0 "	2 3 "	1.7 "
3. Semi-fine .	100 "	95.5 "	2.5 "	2.0 "
4. Medium .	100 "	94.5 "	3.0 "	2.5 "
5. Coarse . .	100 "	94.5 "	3.2 "	2.3 "
6. Very coarse .	100 "	94.0 "	3.5 "	2.5 "
German Pulled Wool, holding Lime.				
1. Fine . .	100 kilog.	84.15 kilog.	2.2 kilog.	13.65 kilog.
2. Medium .	100 "	82.25 "	2.6 "	15.15 "
3. Coarse . .	100 "	92.50 "	0.5 "	7.00 "
Algerine Wool, holding Sand.				
1. Fine . .	100 kilog.	80.5 kilog.	2.0 kilog.	17.50 kilog.
2. Medium .	100 "	92.0 "	2.0 "	6.00 "
3. Coarse . .	100 "	90.0 "	2.2 "	7.80 "

CHAPTER IV.

Clearing the Wool of its Impurities.

However carefully the beating process may have been conducted, the wool still remains mixed with foreign substances, which it is important to eliminate. Such are burs, crooked straws, &c. These bodies are so adherent to the wool, that they are detached from it with great difficulty. They are attached, either by a gummy material, or by the interlacing of their filaments with those of the wool. It is at and about the extremities of the staple that straws and burs are fixed, and, in order to get rid of the latter, it is necessary to pull out the wool fibres with them. It is not astonishing that burs should greatly resist our efforts to remove them; for, when we closely examine these little spherules, we see that they are armed with pointed hooks, and unroll into spirals. The bur we refer to is that found upon French, and especially, also, upon Algerine wools.

These impurities are found mixed with wool in the following proportions:—

French Wools.

Thin oat straw—a small quantity.
Other fine straws—a considerable quantity.
Dried grasses—a large quantity.
Burs (in certain districts, none)—merely a trace.

Algerine Wools.

Straw and grasses—very few.
Burs—a large quantity.
Sand—a large quantity.

These impurities are lodged between the neck and the back. This difficulty might be remedied, if farmers would bring the racks in the stables to a level with the heads of the sheep, so that the straw should not fall upon their backs.

Classification of Wools according to their Cleanliness.

All wools are not necessarily dirty, but the exceptions are very few. According to their cleanliness, they are arranged as follows:—

1, English wools; 2, German; 3, French; 4, Australian; 5, Spanish; 6, Morocco; 7, Algerine; 8, Turkish; 9, Buenos Ayrean.

English wools are divided into three very distinct classes; 1st, long; 2d, semi-long; 3d, fine wools: the latter being as yet little known in England, which produces mostly long and semi-long wools. These materials are all very clean, not matted, and consequently it will be useless for us to dwell longer upon the subject, as they do not require cleansing.

German wools are separated into three classes: 1st, fine; 2d, semi-long; 3d, medium. They are very clean, but slightly mixed with grasses.

French wools are divided into three classes: 1st, fine; 2d, medium; 3d, common. They are slightly mixed

with straw and grasses. Those of Picardy, Normandy, and the north contain some straw.

Spanish wools are divided into two classes: 1st, fine; 2d, semi-fine; and are more impure than the French.

Morocco wools are divided into two classes: 1st, coarse and semi-long; 2d, medium. They are mixed with sand and dust, contain many shank locks, and are full of burs.

Algerine wools are divided into two classes: 1st, medium; 2d, coarse and semi-long. They are more or less impure, according to the province in which they are produced. Those from Constantine are mixed with some sand and an abundance of burs. The province of Oran supplies wools containing sand, dust, and burs, but in a less degree than those of Constantine. The burs occurring in these wools are of a spherical shape, and unrolling into spirals become entangled with the meshes. These impurities are the more strongly attached, as their form presents numerous asperities. Some of the wools from the province of Oran are filled with earthy and ochreous substances.

The presence of the enormous quantities of burs in Algerine wools is attributed to a want of care towards the flocks, and the amount of undergrowth in the pastures; but atmospheric influence has also much to do with it, as, from observations made upon this subject, it is acertained that rain increases the number of burs. As for the presence of sand, it may be readily explained by the winds blowing over the great desert. These hot winds always carry with them sand and other impurities, which find a nest among the fleeces of the sheep, and become incorporated with the grease of their wool.

Turkish and Egyptian wools are divided into two

classes: 1st, long and coarse; 2, medium and shanked. They are impregnated with an earthy grease, straws, grasses, and burs. The burs found in these wools are enormous in size, and of an entirely unique form, resembling that of the olive; among which are found some with a diameter as great as that of a quail's egg. They are very abundant, especially in Turkish Asia.

Buenos Ayrean wools are divided into three classes, viz: 1st medium length; 2d semi-fine; 3d fine. They are very full of grasses as well as burs; in fact, the latter so abound in these fleeces, that some of them contain from twelve to twenty per cent. They are in shape spherical, slightly flattened, and do not unroll as easily as those of Europe.

The wools of La Plata are generally fine enough, but unfortunately impregnated with impurities. Their color is a grayish-white.

Different Combinations Necessary for Cleansing Wool.

As has already been said, the impurities contained in wool are more or less difficult of elimination, in proportion to their greater or less adherence to the wool filaments. Sand and dust are easily got rid of by beating, but burs and straws are not so readily removed. In this latter case, the fleeces are to be cleansed either by hand or by machinery.

Before subjecting the wool to this operation, and in order to assist it, it is important to put the fleece through a preliminary process. We must first, in order to show clearly the impurities of the material, dry it thoroughly,

and free it from the natural grease with which it is always impregnated. Without this precaution, the cleansing process would be very difficult. The impurities, instead of being removed, would become fixed in the wool; and this substance being softened by moisture, would be crushed by the rollers. As for dust, it could not, of course, be removed from wet wool.

The cleansing of wool is done either by hand or by machinery. The former method is very imperfect; for, in the first place, it is more costly, and, in the second, it will always leave behind a quantity of little burs and a considerable amount of dust; whereas, when the wool is submitted to the action of the machine, it becomes entirely free from impurities.

Several burring machines are used in France and Belgium. All these machines are more or less imperfect; but the more recently constructed work tolerably well. The machine which appears best to accomplish the desired objects, namely, the unfelting, separation, and dressing of the filaments, and, especially, the complete extraction of all foreign bodies, is that a plan of which is seen in Fig. 17, Pl. IV.

A. Cast iron frame.
B. Spreading table, or endless wire cloth.
C. Feed rollers with card clothing No. 12.
D. Licker-in with card clothing No. 12 to 14.
E. Roller covered with diamond shaped teeth.
F. Angle stripper with card clothing No. 14 to 16.
G. Main cylinder with mounted comb plates.
H. Fluted iron roller for removing coarser impurities.
I. Fluted iron rollers for removing finer impurities.
J. Brush to clear the main cylinder.

K. Driving pulleys.

L. Fanning apparatus.

M. Pockets or troughs for receiving the burs.

The different pieces of this machine are driven at different rates. We give here the relation of the rates per minute to the diameters of the rollers:—

C.	Diameter	5	centimetres	3	revolutions.
D.	"	18	"	2	"
E.	"	35	"	5	"
F.	"	18	"	10	"
G.	"	80	"	6	"
H.	"	15	"	700	"
I.	"	15	"	700	"
J.	"	35	"	40	"
K.	"	20	"	1000	"

The fineness of the card clothing depends upon the qualities of wool to be manufactured; but, with the numbers before mentioned, all ordinary wools may be worked.

The pulleys of transmission for these rollers ought to have a convexity of one eleventh of their width, so that the belts may not slip. The teeth of the comb plates, on the main cylinder, should be fine, and one to each millimetre. These comb plates are fastened by means of screws to iron racks attached to the main cylinder, and should be placed about three centimetres apart.

Adjustments.

In order to effect the cleansing of wool, we must first adjust the intervals to be observed between the different

pieces of the machine. These intervals depend upon the material to be cleansed.

Table of Intervals corresponding to various qualities of Wool.

Names of the pieces of machinery.		Intervals, in Millimetres, for Wool.					
		Fine.		Semi-fine.		Medium.	
		Impure.	Very impure.	Impure.	Very impure.	Impure.	Very impure.
Feed rollers .	. C	3.0	2.8	3.4	3.0	3.6	3.3
Licker-in . .	. D	2.5	2.3	2.8	2.5	3.0	2.8
Roller . .	. E	2.3	2.1	2.6	2.3	2.9	2.6
Angle stripper	. F	2.0	1.8	2.3	2.0	2.5	2.3
Main cylinder	. G	"	"	"	"	"	"
Fluted roller .	. H	1.2	1.1	1.3	1.2	1.4	1.3
Fluted rollers	. I	1.0	0 8	1.1	1.0	1.2	1.1
Brush . .	. J	"	"	"	"	"	"

Method of Operating.

We begin by spreading the wool evenly on the feed table. The woman charged with this work takes the wool in her left hand, and draws it from above downwards so as to give all its meshes the same direction.

As soon as the wool reaches the feed rollers, it becomes engaged between them, and, on leaving them, encounters the licker-in, which carries it at once to the roller *E*, having a clothing of diamond-shaped teeth, whence it passes to the fluted iron roller *H*, making 700 revolutions a minute, and which relieves it of some of its impurities. The angle stripper *F* then takes it thus partially cleansed to the main cylinder, which, in turn, carries it under the fluted iron rollers *I*, making, like the preceding one, 700 revolutions a minute. On emerging

from these burring rollers, the circular brush strips the wool from the main cylinder, and, while separating the filaments, throws it forward with such velocity that, if there still remained any dust, it would be removed and absorbed by the helicoidal fan.

When this operation has been properly conducted, it may be seen from an examination of the wool leaving the apparatus; the material should be completely free from impurities, well opened, and flaky. In this condition, the wool may be washed and subjected to the other subsequent operations without much loss.

This burring machine requires one and a half horse power, and, with the help of one woman and a child, will prepare about 150 kilogrammes of wool in twelve hours.

CHAPTER V.

Washing.

The wools of commerce are naturally greasy, the amount of natural grease contained varying with the source from which the fleece is derived. The wools of the North, for instance, having been carefully either fleece or tub-washed, are much cleaner than those of the South, where they are not washed at all, but delivered in grease. Thus the wools of Turkey, Egypt, Algiers, and Morocco arrive in grease at Marseilles, and are frequently washed in that city before being distributed to different points of the French territory.

Natural Grease.

This grease is composed of soluble and insoluble substances. The soluble result principally from the secretion of sweat, more or less modified by the oxygen of the atmosphere; while the insoluble are generally products of the soil and of accident.

This natural grease is unctuous to the touch, and of an aromatic smell. Its quantity depends upon the nature of the sheep and upon the surface of the filaments of wool. The finer the wool, the more it is charged with grease, and conversely. Thus, merino wool, which is very fine, contains two-thirds of its weight of grease. The quantity of this substance is so variable, that some wools lose in washing from 50 to 75 per cent. of their original weight, while the loss of others does not exceed 20.

[We shall call "washing" the first operation, by which the portions of natural grease soluble in water are extracted in cold or warm water. These soluble portions are a kind of natural soap very rich in potassa. The next operation will be the "scouring process," by which the insoluble natural grease and other impurities are removed with the aid of soap or alkalies.—*Trans.*]

There are several methods of washing adopted in France, which we shall examine successively, while, at the same time, we explain the scientific principles of the operation.

Marseilles Washing.

In Marseilles cold water is used for washing. The wool is immersed in great wooden or zinc vats, sunk to

a certain depth in the ground, by the river side. The workmen stand by with long sticks and stir the wool in every direction to facilitate the extraction of the grease. The washing terminated, the wool is placed upon a tray and the whole carried to a pebbly beach. By turning it over from time to time, five or six hours are sufficient to completely dry the material.

Washing in the North of France.

In the North of France the wool is either fleece or tub-washed. Fleece washing is generally performed in a stream or a sheet of water, but running water is preferable. The force of the current carries off the soluble grease and the water is constantly renewed.* This work is generally performed by women.

In the first place, two women take hold of the sheep by two shanks and give him an oscillating motion, in order that the water may penetrate his fleece freely and dissolve the soluble parts, while a third woman increases the effect of the operation by rubbing and kneading the wool and pulling off the dirt adherent to the lower thighs.

When the wool is thoroughly washed its appearance is very white, and the running water no longer carries off any grease. This method of scouring is in use in Picardy, Normandy, l'Oisé, etc.

* The great quantity of potassa in the natural grease of wool has given rise in France to works for saving this alkali from the washing liquors. Farmers who wash their sheep would do well, local circumstances permitting, not to lose the water used for that purpose, as it possesses great fertilizing properties.—*Trans.*

Washing as performed in Pas de Calais, the North, the Ardennes, etc., consists in plunging the fleeces into tubs filled with warm water. The water is renewed from time to time, and, finally, the fleeces are allowed to dry.

Fleece-washed wools should contain but little grease and be very white; they are shorn a few days after washing. Wool thus treated is very well adapted to manufacturing; it is easily beaten, can be scoured in one operation, and, moreover, preserves the form which it had upon the sheep; whereas that shorn in grease and washed with sticks is mixed and often felted, which occasions much loss and yields a poorer product. It may be remarked that the less wool is touched by water the more it preserves its virginal form, and this is what occurs in fleece washing.

Analysis and Theory of Washing.

By Mr. Chevreul.*

"The proximate principles of wool are:—

"1st. A greasy substance solid at the ordinary temperature, but perfectly liquid at 60° Centigrade.

"2d. A fatty substance fluid at 15° C.

"3d. A filamentous material constituting the wool proper.

"Wool contains at least three proximate principles; for, according to my observations, the filamentous part disengages sulphur and hydrosulphuric acid, without losing its characteristic properties; and hence, it has

* Extract from the report of the *Académie des Sciences,* 1840, and that of the Exposition of 1844.

seemed to me that sulphur, in its elementary condition, enters into the composition of a body distinct from the filamentous material proper.

"By acting upon wool with nitric acid, and after that by chloride of barium, the quantity of sulphuric acid produced by the sulphur of the wool will be known, and I have found that 100 parts of that substance, in the condition in which it is employed, contained 1.78 per cent. of sulphur.

Fatty Matter Contained in Wool.

"The fatty matter, which I have isolated by means of boiling alcohol, is composed of two proximate principles, corresponding by their difference in fluidity, to stearine and oleine, whence I have designated them respectively *Stéarérine* (wool-suet) and *Elaërine* (wool-oil), though they differ absolutely from stearine and oleine in several of their properties, and notably, in not being saponifiable by means of alkalies.

"The stearerine is not perfectly fluid below a temperature of 60° C., while elaerine is liquid at 15 degrees, and both are neutral to colored tests.

"If we seek to ascertain the amount of fatty material contained in wool, by washing it with distilled water, and drying it at 100° C. (212° F.), we shall be astonished to find that it reaches from 20 to 28 per cent., and that the wool is still not entirely free. This is, nevertheless, the result of two experiments with two samples of merino wool, one taken from a lamb, and the other from an ewe. I am far, however, from affirming that wools of different breeds contain the same proportion of greasy matters, for,

thus far, my experiments have been confined to merino wools.

"As to wool which has been subjected to the operations of washing and scouring on a large scale, we find that alcohol will only remove 0.03 part of fatty matter; whence it follows that it still loses 17 of 100 parts in the treatment to which it is submitted, before being spun and dyed.

The Operation of Washing and Scouring.

"If wool were treated only with pure cold water, we should separate the soluble parts of the natural grease, but some greasy parts would remain attached to the filaments, and retain the finer portions of sand and earthy matters which are always present in the fleece. These earthy particles, being themselves more or less colored, would impair the whiteness which is required in perfectly scoured and washed wool.

"What then is done in working on a large scale? The water of the tub or caldron is charged with the soluble part of the natural grease, which renders it alkaline and as it were soapy, though this material cannot exactly be likened to soap; the alkalinity of the water is then increased by the addition to it of ammoniacal urine, carbonate of soda, or soap. After this, the action of this alkaline solution is further increased by raising its temperature to from 50 to 65 degrees C. When this is done, the greasy substances form with this warm alkaline liquid, not a solution, for the substance will not saponify, but an emulsion which, being persistent, separates from the wool. The stability of the emulsion is moreover

increased, by the addition of some earthy material,* which serves to retain the grease; and, finally, by means of the brisk stirring which the wool undergoes in the hampers, baskets, and cases, where the water is constantly renewed, every foreign substance, which can be removed by mechanical means, and the soluble material of the liquid in the caldron, are eliminated.

"If we wish to appreciate the influence of the temperature and alkalinity of the water in the process of scouring, and thus become convinced of the necessity of removing the greater part of the fatty matters of the wool, so as to obtain the most brilliant white, let us consider the following observations:—

"1st. Cold water containing carbonate of soda will form an emulsion with wool washed with distilled water, while pure water will not. The former liquid, when separated from the wool, throws down an earthy material, which yields to alcohol much stéarerine and elaerine; and the turbid liquid, separated from this precipitate, and evaporated to dryness, is found to yield still more to the same solvent.

"2d. The water, in which the wool is digested at 75° C., after being washed in cold distilled water, becomes emulsive; for, a portion of the grease, though indeed quite small, is disseminated through it.

"3d. The following table represents the respective proportions of materials, which I have removed from a merino fleece, their weights having been determined by the degree of solution to which they attained at a temperature of 100° C. (212 F.)."

* A mixture of clay and lime is often employed.

Earthy matters deposited from the distilled water in which the wool was washed		26.06
Natural grease dissolved by cold distilled water		32.74
Wool washed with cold distilled water.	Greasy matters composed of stearerine and elaerine	8.57
	Earthy matter fixed in the wool by the greasy matter	1.40
Wool washed with alcohol		31.23
		100.00

Another Method of Washing.

Instead of washing by one operation, there are some manufacturers who put the wool through three or four. First, they allow the wool in grease to digest for some time in tepid water at 20 to 25° C., then carry it to a second bath of warm water at 25 to 30° C., and finally, when it has thus remained for some time, they throw it into a tub or vat, like our own, and they treat it as we do; but this process is tedious.

Press Washing.

In order to conduct machine washing properly, we must, first, be provided with a large quantity of warm water, in close proximity to the washing apparatus. The water is kept at an uniform temperature, by putting up in the place intended for these sorts of operations, a great vat analogous to that represented in Fig. 18, Pl. V.

A. Wooden frame.

B. Large vat of galvanized sheet iron.

C. Pipe for the introduction of cold water.
D. Entrance faucet.
E. Cover with bolts.
F. Steam pipe.
G. Steam cock.
H. Waste pipe.
I. Discharge faucet.
J. Safety valve.
K. Thermometer.
L. Level gauge (glass tube).

In order to fill this vat, water is introduced through the pipe C, and as soon as the vat is full, which is ascertained from the gauge L, the entrance faucet is closed. The steam is then let on through the pipe F, and the water becomes quickly heated. When it has attained the required temperature, say 85 or 90° Centigrade, it is kept at that degree, which may be readily observed on the thermometer K, placed near the faucet I. At the same time, should there be an excess of steam in the vat B, it would escape through the safety valve. As soon as these arrangements are made, the process of washing may be begun.

As this method of washing requires the additional aid of a special apparatus, we here give a description of the machine constructed by Mr. Brunneaux, Senior, of Rethel. (Fig. 19, Pl. V.)

A. Cast-iron frame.
B. Large trough.
C. Endless cloth.
E. Turned cast-iron roller.
F. Cast-iron pressure roller covered with wool.
G. Levers.

The Operation.

The trough B is first two-thirds filled with warm water, the wool in grease placed near at hand, so as to be readily manipulated, and, before commencing the operation, the temperature of the water in the trough is ascertained; it should not exceed 65 to 70° C. for very greasy wools, and 60 to 65° C. for those less impregnated. About 26 to 30 kilogrammes of wool are then immersed into the trough.

The wool is stirred with a stick for a minute or so, in order to let the warm water penetrate the grease and dissolve it, and is then raised by small portions at a time, and spread upon the endless cloth C, which carries it to the rollers E and F. The pressure exerted by these rollers is sufficient to allow nothing but the wool to pass between them, and the liquids charged with greasy substances flow through the gutter placed under the roller E into a small separate reservoir, in order not to soil the water bath; while the wool, after leaving the rollers, is dropped into a basket. (See Fig. 24, Pl. VI.)

Great care must be exercised to see that the temperature of the water in the trough is kept uniform, for, after a certain quantity of wool has been immersed, it cools. As soon as the water in the trough is perceptibly soiled, it is drawn off to be reserved for other operations, and a fresh supply let in.

When the operation is well conducted, the wool is no longer matted, and has a soft, supple feel to the touch; whereas those treated with cold water and sticks become mixed, hard, dry, and often felted.

The water used in washing is excellent for again treat-

ing other wools, but it must be purified from all the dirt it has received. For this purpose it will suffice to employ a light felt filter in an apparatus recently invented for the purpose.* The soiled water is poured in, and is filtered so as to be quite clean, and easily kept for a considerable time.

Washing in a Current of Warm Water.

The rotary apparatus for washing by a current of warm water is constructed as follows: (See Fig. 20, Pl. V.)

A. Vat holding four hectolitres of warm water.
B. Wire gauze cylinder.
C. Transverse shaft of the cylinder B.
D. Opening with a slide for introducing wool.
E. Pulleys.
F. Steam-pipe.
G. Steam-cock.
H. Discharge faucet.

Method of Operating.

As in the ordinary method, warm water is poured into the vat A. The wool is then introduced through the opening D, the pulley E thrown into gear, the cylinder B set in motion, and the rotation continues. The warm water softens and dissolves the natural grease, which is given off during the rotation of the wool, and, in this way, a regular current of warm water is produced. The circumference velocity of the wire cloth should

* Mr. De Villepoix, chemist at Abbeville (Somme).

not be less than 250 metres per minute. After a few moments of this rotation, the wool is withdrawn and passed through the rollers of the ordinary washing machine.

Washing by a Current of Cold Water.

To wash by this means we must have running water, as, for instance, a waterfall, or the operation may be carried on below a water wheel.

Two pieces of timber are set up vertically in the current, and support a large wire cloth cylinder similar to that described in the preceding article. This is filled with wool in grease, and turned in all directions, with a slight velocity, to the right and left of the current. The washing is thus effected, and the wool is then taken from the apparatus to the wringing rollers. This mode of washing is perhaps less costly than the others, but is open to the objection of hardening the wool.

One and a half horse power, one workman and two helpers are required to work a washing or wringing machine such as that of Mr. Brunneaux, of large size; and in twelve hours we can wash:—

Fine wools—650 kilogrammes.
Semi-fine—725 "
Common—800 "

CHAPTER VI.

SCOURING.

THE first washing process does not entirely eliminate all impurities and greasy matters from the wool, and we are therefore obliged to subject it to a second operation, which shall free it from the last traces of grease, and render it fit for carding and other manipulations. This end is obtained by the scouring process.

After being washed, the wool is treated by solvents, such as soap and carbonate of soda; but this latter agent must be used with caution, as it may attack the wool itself and convert it into soap, especially if the water is used at a high temperature. The scouring is carried on in the same place as the washing, and the utensils are the same, with some slight modifications which we shall mention further on.

CHEMICAL AGENTS USED FOR SCOURING.

It is of great importance that the agents used for dissolving the grease should be of superior quality. If we seek cheapness in this particular, we shall find it to be very poor economy. For instance, common soap should never be employed, as being, for the most part, entirely unfit for the operation.

Manufacturers are often much at loss as to the choice of soap they should make for this purpose; and we accord-

ingly give the lists of those which are to be avoided, and those which may be employed.

To be avoided:	Green (soft) soap. Rape-seed oil soap.
May be used for wool waste:	Argilo-calcareous soaps. Potash in general.
Good soaps:	Hard French soap (Menuel). " Marseilles soap (Trefoil mark). Half white " " White " " Carbonate of soda (soda ash, crystals).

The first class of these soaps is very rich in alkaline principles, but very poor in the fatty ones. These soaps of poor quality contain a considerable amount of mucilaginous matters, which it is difficult to saponify, and then only by the use of large quantities of potash, rendered caustic by the presence of lime. The potassa soaps are very bad for scouring, as they at once attack the wool filaments, and very greatly impair the material.

WATER. INCONVENIENCE OF CALCAREOUS WATERS. MEANS OF NEUTRALIZING THEM.

The peculiar nature of the water used in washing and scouring wool has much to do with the success of the operation. As far as possible we should employ either river or rain water, and preferably the latter.

Waters charged with calcareous substances are very bad; they impair the efficacy of the soap-suds, and thus increase the expense of the process. Among such are spring, fountain, and well waters.

It is of much importance that the manufacturer should be able to ascertain the qualities of the water he employs, and to know whether it will easily dissolve soap. For this purpose he should dissolve a piece of soap in the water he desires to test, and if the resulting suds are flaky and turbid, instead of being clear, the water is incapable of dissolving soap, and unfit for use.

The presence of lime may be recognized by means of oxalate of ammonia. In ten grammes of distilled water dissolve one gramme of crystallized oxalate of ammonia, and pour a few drops of the solution into a glass containing the water to be tested. The presence of lime is indicated by the formation of a white percipitate.

To neutralize the injurious effect of calcareous substances, we may dissolve in the water of the main supply reservoir 100 grammes of soda ash to the hectolitre (about 26.5 U. S. gallons or 22 imperial gallons). This fact is especially important to manufacturers who cannot avail themselves of river water.

Iron is frequently found in water, but when present only in small quantities does no harm.

The water of the main tank, kept at the temperature already indicated for washing, will serve to feed the scouring apparatus.

Solution of Soap.

The first thing to be done in scouring is to prepare a supply bath of soap suds to feed and saturate the other baths of the scouring room; and I, accordingly, give a description of an apparatus of my own invention for the solution and preservation of soap. (See Fig. 21, Pl. V.)

A. Copper tank 1.50 metre high, by 1 metre diameter.
B. Steam pipe for heating the solution.
C. Opening for letting in soap and water.
D. Vertical shaft supplied with a crank or pulleys.
E. Discharge faucet.
F. Brick or stone work.
G. Horizontal bars fixed to the vertical shaft D.

In order to obtain a saturated solution of soap with this apparatus we supply it with water from the main tank; and the soap, having been sliced, by means of a common jack plane, into shavings sufficiently thin to readily dissolve, is introduced through the orifice C in the following proportions:—

Water 100 litres (1 hectolitre = nearly 26.5 U. S. gallons, or 22 imperial gallons).

Soap, 15 kilogrammes (33 lbs. avoirdupois).

Before incorporating the soap, the temperature of the water is raised to 90° C. The crank is then turned, or rather the pulley is thrown into gear, the soap becomes softened by the heat, and the water being constantly stirred, dissolves it entirely. As soon as the solution is completed, we add 50 litres (½ hectolitre = 13.25 U. S. gallons = 11 imperial gallons) of warm water.

Method of Scouring and Manipulation.

Since the machine employed for scouring is the same, as we have already said, as that used in washing, it would be useless to describe it anew, and we will therefore pass directly to the manipulation.

1st. Let in the vat 400 litres (4 hectolitres) of warm water.

2d. Take 40 litres of the saturated solution, and pour it into the 400 litres of warm water, stirring the liquid so as to mix the solution well, and recollecting that, before introducing it, the temperature of the water should have been raised

from 50 to 55° C. for very greasy wools,
" 47 to 50° C. " medium greasy wools,
" 44 to 47° C. " the least greasy wools;

then add 300 litres of warm water, 30 litres of the saturated solution, and stir.

3d. In order that the bath may not change its temperature, the wool is added in small quantities at a time. The second assistant is charged with this duty, and by means of a stick, he turns it over and over so that every portion of the filamentous material may come in contact with the solvent liquid. The workman then takes this scoured wool and spreads it on the feeding cloth to be carried under the rollers, which press out the fluids it contains, and the wool falls into a basket. (See Fig. 24, Pl. VI.)

4th. This bath is kept at a uniform degree of temperature and alkalinity, either by heating it with a jet of steam or by adding from time to time a sufficient quantity of the saturated solution; never, however, allowing it to thicken, as the wool, instead of being scoured, would become soiled.

5th. These baths, after having been used for a certain quantity of wool, become thick, dirty, and no longer fit for use. They are then poured into great vats to be converted into soap.

6th. Generally, a well-washed wool, properly beaten, does not require more than one scouring.

7th. Each time a new bath is made, the bottom of the vat should be cleansed, as the earthy matters being very heavy are precipitated, and might affect the fresh solutions.

A word or two will be sufficient to explain the theory of washing. The temperature of the solvent liquid having been raised to about 50° C., it acts upon the grease of the wool filaments, and softens them. Very soon these greasy matters become detached and saponified, forming a fatty neutral soap. After having cleansed a certain amount of wool, the bath thickens, becomes greasy, and no longer possesses its former saponifying properties, so that we must add soda or more soap. The former means is the most natural, as soda has a much stronger saponifying power than soap; for, as the latter is composed of soda and oil, the oil neutralizes part of the effect of soda.

54 parts by weight of carbonate of soda, at 36 alkalimetric degrees, saponify 100 parts of olive oil.

It may thus be seen that old baths may be readily reinforced, so long as they have not become very thick. For this purpose, it is sufficient to filter them through de Villepoix's apparatus, and add potash in the proportion of one kilogramme to the hectolitre; but, I repeat it, these old baths can only serve for scouring very greasy wools.

Experience shows us that the quantities of soap to be used in scouring are proportionate to the surface and thickness of the greasy matters surrounding the wool filaments; and, therefore, the finer a wool is, the more soap it will require.

The quantity of soap to be employed for a greasy

specimen depends upon the nature of the wool; whereas, dry fleeces have to be treated with caution, by using neither too high a temperature nor too strong an alkaline solution.

Temperature of the Bath—Amount of Soap to be Employed for each Quality of Wool.

We say, as a general rule, that wools must be treated according to their individual qualities. The following is a table of approximative estimates:—

Table of the Proportion of Soap to be used in Scouring, and the Elevation of Temperature for different qualities of Wool.

	Qualities of the wool to be scoured.	First Scouring.		Second Scouring.	
		Temp. of the bath.	Quantity of soap for 100 kilog. of wool.	Temp. of the bath.	Quantity of soap for 100 kilog. of wool.
For numbers of yarn.	225	60° C.	12 kilog.	58° C.	6 kilog.
	180	59	11 "	57	6 "
	160	58	10 "	56	5 "
	145	57	9 " 500 grm.	55	5 "
	130	56	9 "	54	4 " 500 grm.
	120	55	8 " 500 "	53	4 " 500 "
	105	54	8 "	52	4 "
	95	53	7 " 500 "	51	4 "
	85	52	7 "	50	3 " 500 "
	70	51	6 " 500 "	49	3 " 500 "
	55	50	6 "	48	3 "
	30	49	5 " 500 "	47	3 "
	25	48	5 "	46	2 " 500 "
	20	47	4 " 500 "	45	2 " 500 "
	15	46	4 "	44	2 "
	10	45	4 "	43	2 "

If about the proportions given in the above table are used, it will often happen that the wool will be hard or

felted; nevertheless, these quantities being only approximative, cannot be followed as an absolute guide. For instance, wools from different sources may vary in the amount of grease they contain, and such a variation would affect the correctness of our figures.

Wool frequently hardens in scouring, and this result denotes that it is of a kind little impregnated with grease. Such a material should be treated with caution, using only a light soap bath with a mean warmth of about 40° C., and diminishing the temperature if the liquid is too alkaline.

The success of scouring depends mainly upon the two following conditions:—

1. Temperature of the bath.
2. Alkalinity of the solution.

When fleece-bound wools are treated, they should be subjected to a mild warmth in quite a caustic solution, in order to destroy the material by which the filaments are bound, and which is soluble in alkalies.

Among the wools which still retain much grease after washing, we should mention the Australian and the English. These wools, notwithstanding that operation, contain much fatty matter insoluble in warm water. In order, therefore, to purify them properly, they should be treated with strong soap-suds, raised to a temperature of 55 to 60° C. We cannot too strongly advise manufacturers to ascertain the exact temperature of the baths. They should be provided with a thermometer graduated with the greatest care, and capable of resisting a temperature of 100° C. (212 F.).

For this purpose, I have myself had a thermometer made, which will resist high temperatures, and bearing

upon its scale, opposite each degree of heat, the corresponding quality of wool, or that which requires to be raised such a degree before being thoroughly scoured.

It must be remembered that all that has been said has reference to wools sorted in the fleece, and not those cleansed by a burring machine, which should be treated at a temperature at least 5 degrees C. lower than the former, the degree of alkalinity of the baths still remain- the same.

Pulled wools (mortlings) are treated in baths 2° C. lower in temperature than for fleece wools, the solution containing considerable soap, but no potash; for, should this agent unfortunately be present, caustic potassa would be formed, and the wool destroyed.

Felted wools are treated at a low temperature.

The felting of wools has attracted the attention of the learned, and the opinion most generally admitted is, that wool is bearded like rye. In following the staple from the root to the point, the surface is smooth to the touch; but, in the reverse direction, a resistance or catching is felt; this structure explains the felting or tangling which results, especially when the wool is freed from its lubricating grease by the process of washing. It is possible that these barbs, though imperceptible to the naked eye, are of the same nature as the wool filaments themselves, only finer, and that they become saponified by a high temperature, or too strong an alkaline solution.

The machinery being the same as that used for washing, we find that one workman and two assistants, and one and a half horse power will accomplish, in twelve hours' work, the scouring of:—

Fine wools	600 kilogrammes.
Semi-fine wools . . .	650 "
Common wools . . .	700 "

It should be remembered that the cost of the operation will be the greater, if we do not make use of the condensed water, which comes to the main reservoir at a temperature of 40 to 50° C.

Yarn Scouring.

Yarns or worsteds are not generally scoured in the spinning mill; nevertheless, as in certain branches of industry, such as tapestry, trimming and fringe making, &c., only scoured and doubled yarns or threads are used, we have thought it right to say a word or two on the subject.

This scouring (by some persons called washing) requires great care, and the threads or yarns are the more difficult to scour, in proportion as they contain a greater amount of greasy matters, and are more tightly twisted. They act, during scouring, in the same manner as wools; but, before submitting them to the operation, it is important to twist or fasten the hanks, so that they may not ravel. For the particulars of this process, we refer our readers to the article on hank twisting.

Mode of Operation.

The bath is prepared in the Brunneaux washing or scouring apparatus, as in the case of wool. The twisted hanks are fulled and thrown into the bath, raised to the

temperature indicated in the following table prepared for that purpose. The bath may contain about 300 kilogrammes of hanks. Too high a temperature, in the case of certain qualities, makes the yarn yellow, as we have already mentioned in regard to wools, which also become yellow and dry.

After a few minutes a workman standing in front of the endless feed cloth, makes a hollow at one end of the bath by withdrawing some of the twisted hanks, while another workman, on his right, untwists a hank and passes it to him. The first workman then dips it into the bath, moving it about, and sliding it through his left hand, so as to squeeze out the soap; he then places it on the feed cloth, which carries it under the rollers, while an assistant, standing behind them, receives the hank, twists it at one end, and places it on a strainer, whence it is carried to be rinsed.

One and a half horse power is required, and in twelve hours one man and two assistants will scour:—

Fine wools . . .	350 kilogrammes.
Semi-fine wools . .	400 "
Common wools . .	450 "

The following table gives the amount of soap required by different qualities of material and the corresponding elevations of temperature:—

Table showing the quantities of Soap, and the Elevation of Temperature, for Scouring various qualities of Worsteds and Yarns.

Qualities of the wool to be scoured.	Scouring of Combed Yarns (Worsteds).		Scouring of Carded Combed Yarns.	
	Temp. of the bath.	Quantity of soap for 100 kilog. of wool.	Temp. of the bath.	Quantity of soap for 100 kilog. of wool.
Number of the yarn. 225	55° C.	8 kilog.		
180	54	7 " 600 grm.		
160	53	7 " 200 "		
145	52	6 " 800 "		
130	51	6 " 400 "		
120	50	6 " 000 "	52° C.	6 kilog. 400 grm.
105	49	5 " 600 "	51	6 " 000 "
95	48	5 " 200 "	50	5 " 600 "
85	47	4 " 800 "	49	5 " 200 "
70	46	4 " 400 "	48	4 " 800 "
55	45	4 " 000 "	47	4 " 400 "
30	44	3 " 600 "	46	4 " 000 "
25	43	3 " 200 "	45	3 " 600 "
20	42	2 " 800 "	44	3 " 200 "
15	41	2 " 400 "	43	2 " 800 "
10	40	2 " 000 "	42	2 " 400 "

Rinsing.

This process removes the last traces of soap remaining on the surface of the threads, and prepares them for dyeing.

Rinsing, to be successful, requires:—

1st. That the yarns or threads should be well scoured.

2d. That they should be rinsed in a rapid current of water, such, for instance, as flows behind a water wheel.

For the purpose of rinsing, a cask is sunk on the shore of the stream in which the workman places himself, and taking a double hank he dips it into the water and moves it rapidly to and fro, in order to cause the yarn to give

up the soluble materials it contains. The hank thus rinsed is placed upon a sieve or strainer and carried to be dried.

Wringing.

This operation consists in depriving the yarn of the superabundant water it retains after being rinsed, and may be effected by placing the yarn under a press, or between two fine nets, or, better still, by means of a machine wringer called hydro-extractor. By the first method, the yarn becomes flattened; the second is slow; whereas by the third we can do more work with a better result. (See Fig. 22, Pl. VI.)

A. Cast-iron casing, serving for a support plate.
B. Friction plate.
C. Movable friction pulley.
D. Lever directing the friction pulley.
D′. D″. Hand wheel moving the lever.
E. E′. E″. Three uprights supporting the transmission.
F. Shaft of the drying basket.
G. Drying basket.

Mode of Operating.

The yarn is placed in the basket and the friction plate B set in motion, taking care to raise the movable friction pulley C near the centre. The rotation commences slowly, but, by means of the hand wheel D, the pulley is progressively directed toward the circumference, and the number of revolutions goes on increasing to 650,

which is the limit fixed upon by the constructor of this machine.*

This is what takes place during the motion of the apparatus, the fluids contained in the yarn have a tendency to fly from the centre of rotation and pass through the apertures in the basket of wire-cloth, while the yarn, held back by the grating, remains behind. Now, in mechanics, we recognize two forces, viz: the centripetal force, which, as its name indicates, attracts bodies towards the centre; and the centrifugal, which, on the contrary, tends to throw them off from the centre. These forces act in this hydro-extractor: water, being a liquid, has a tendency to leave the centre through the centrifugal force, whereas the escape of the wool is arrested by the sides of the basket, which may be held to represent the centripetal force.

A few minutes will suffice to wring 25 kilogrammes of yarn. As soon as the material leaves the machine it is carried, during the summer, into the open air, and in the winter, to a drying room.

Uses for Old Baths.

Old baths, having become too thick, can no longer answer the purpose of active solvents, and yet they may be still put to advantageous uses. They should be allowed to rest for several days in large vats, and then

* Mr. Tulpin, Senior, engineer, Rouen. We cannot too highly recommend the use of this drying machine, which is already employed in a large number of manufactories. It requires but a small power, since the number of its revolutions, instead of being 1000, as in several similar machines, is limited to 650.

be filtered through de Villepoix's apparatus. The liquid should be neutralized in order to separate the fatty matters by means of some cheap acid, the best, in our opinion, being sulphuric acid.

After filtering, the acid is poured into these old baths until the soap is decomposed. It combines with the soda of the soap, forming sulphate of soda, while the fatty substances, set at liberty by the combination of the soda, rise to the surface of the liquid and are skimmed off by means of a ladle or cullender, after the liquid has been at rest. These materials may be saponified again, but they will only produce inferior soaps.

We have also succeeded in using the refuse from old baths for the manufacture of illuminating gas. The gas produced by this process is very handsome as well as cheap, especially in establishments where the consumption of soap is very large. The apparatus costs very little to put up. I have seen several of them made by Mr. Nicolas, of Croix-lès-Roubaix (Nord).

Wool Picking.

It is not often that wools designed for combing (worsteds) need to be passed through the picker, which is rather intended for those to be carded. Still we do often find, while manufacturing, some hard and felted wools, more or less difficult of separation, which it would not be proper to subject to the process of carding, as the clothing of the cards would inevitably suffer. They are, therefore, passed through a machine with the object of opening them and rendering them more supple, which machine is called a picker or willow. (Fig. 25, Pl. VI.)

A. Cast-iron frame.
B. Drum covered on its surface with steel teeth.
C. Wooden cover.
D. Pressure lever.
E. Pulleys.
F. Feed rollers.

The operation consists in spreading the wool on the table, when it is taken up by the feed-rollers, and carried to the drum with the steel teeth. The feed-rolls move slowly, and the drum very quickly, so that the wool is separated and forcibly thrown forward. It is then picked up and carried away in baskets to dry.

Drying.

The wool, on leaving the scouring machines, is dried and oiled, in order to be submitted to the card breakers. Drying, for some years past, has been done by means of hollow copper cylinders, covered with wire cloth, and through which passes a current of steam. The wire cloth moves with the cylinders, so as to carry along the wool, and expose it to their heat. As fast as the wool becomes heated, it is met by a current of hot air, let in from below, which carries off the products of evaporation and dries it, there still, however, remaining behind six per cent. of water combined with soap. After leaving this machine the wool is oiled.

In default of this machine, the wool is carried to a large drying-room. This room should be square, and supplied with pipes conveying a current of hot air; or, it may equally well be uniformly heated by the warmth

from steam pipes. There are several methods of heating, viz:—

1st. By large stoves.
2d. By hot air ventilation.
3d. By steam currents.

The first two methods are very active, and dry the material very quickly, though with some danger to its quality, by the want of regularity in the process, leaving portions of the wool dryer than others, and thus occasioning a waste in carding. For this reason we adopt the third method, which dries uniformly, especially at a temperature of 40 to 45° Centigrade.

As we have said, the yarn, after being wrung, is hung out upon poles, in summer, or carried to the drying-room in winter.

For this purpose, poles are arranged, from which the hanks are suspended, while other poles are passed through them to stretch and dry them properly. Tension, in this case, favors the drying and renders the yarn smooth. When the hanks are thought to be half dried, they are turned, so as to reverse their position.

CHAPTER VII.

OILING.

Disadvantages of not Oiling.

Several establishments, where carded wool is spun, have erroneously, as we shall soon show, given up oiling their material, thinking that they find the new method economical.

This "moist" process consists in suppressing entirely the use of oil for wool intended for carding, so that the wool directly passes on to be carded after drying, while it still contains from 8 to 12 per cent. of moisture combined with soap.

For fine wools	12 per cent.
" medium wools . . .	10 " "
" coarse wools	8 " "

Now, wool is more flexible when wet, and more elastic when oiled; so that, for instance, if we subject two moist wool filaments, one of which has been oiled, and the other not, to the strain of a small weight of 20 grammes, the first will elongate, whereas the second will yield and break. This experiment, evidently, goes to support our principle: that wool cannot undergo any tension in carding, without breaking, especially if it has not been oiled, and that a great loss of material will thus be produced.

Water evaporates at the ordinary temperature, while oil does not. Water by evaporating during the first operation of carding, leaves the wool so dry as often to be unfit to undergo a second carding; while oil, on the other hand, being more fixed, covers the surface of the wool until the slivers are scoured.

Experiments upon the Relative Advantages of Oiling and not Oiling.

As we have said in the chapter upon scouring, wool filaments are covered from root to point with imperceptible barbs, and it is evident that, if not oiled, they will

lose by friction with each other, during the operation of carding, a portion of these little barbs, which are so useful in binding the filaments together for the formation of yarn. On the contrary, if the filaments have been previously oiled, the barbs can easily touch each other without being perceptibly injured, and the filaments will slide through the teeth of the card without suffering much loss of substance, except in the case of such stiff and heavy fibres, as will not mix with the wool proper.

The use of fluid fatty substances in oiling, is the basis of successful and productive carding.

Oil possesses the property of rendering wool supple and adapted to carding, and its use should therefore be preferred to the "moist" process, which, on the contrary, destroys the qualities of the wool by the repeated jarring and stretching produced by carding.

The following experiments have been made, so as to give a better idea of the relative results:—

First Experiment.

100 parts by weight of semi-fine oiled Picardy wool were subjected to the action of a breaker: the card clothing was No. 24, and the temperature of the carding room 18 degrees centigrade.

Product in scoured carded wool .	80.00	parts.
Collected waste (flyings) . . .	0.90	"
" strippings	0.60	"
Loss in carding	1.20	"
" scouring	17.30	"
	100.00	

Second Experiment.

100 parts by weight of semi-fine unoiled Picardy wool were submitted to the same breaker, at the same temperature.

Product in scoured carded wool .	78.50	parts.
Collected waste (flyings) . . .	1.00	"
" strippings . . .	0.70	"
Loss in carding	2.50	"
" scouring	17.30	"
	100.00	

From these two experiments we see that the unoiled lost 1.5 per cent. more than the oiled wool, and the difference between the two products is so great that it is easy to manufacture two or three numbers finer yarn with the first than with the second.

The experiments, therefore, show conclusively how imperfect a result is obtained when the wool is not oiled, and how important it is that it should be.

Oils to be Employed.

Oiling is effected by means of a greasy substance, sufficiently fluid to afford elasticity to the wool. The liquid oils are, therefore, the most suitable, and the more liquid they are the better.

Properties and Specific Gravities of Oils.

Kinds of oils.	Specific gravity, water = 1000.	Degrees of fluidity.
Poppy-seed oil	939	Fluid.
Linseed oil	932	Less fluid.
Rape-seed oil	931	Less fluid and slimy.
Beech oil	923	Fluid and somewhat slimy.
Olive oil	913	Very fluid at + 15° C.
Oleine	910	More fluid.

Oleine,* being the most fluid and the lightest, should be employed in preference; but unfortunately it is not saponifiable at the same degree as the others, and necessitates a larger amount of soap to wash it from the surface of the wool. When mixed with olive oil, its fluidity is not impaired, and it consequently penetrates the wool equally well.

Oils are very expensive when used pure, and they are, therefore, mixed with a solution of soap and the resulting liquid is called "composition."

Composition for Oiling Wools.

In one hectolitre (26.5 U. S. gallons or 22 Imperial gallons) of warm water dissolve:—

Soft Picardy soap . . . 15 kilogrammes.

To this add one hectolitre (100 litres) of oil, composed as follows:—

Oleine	50 litres.
Olive oil	50 "

* Oleine often contains some sulphuric acid. This impurity should be removed before the oleine is employed by the woollen manufacturer. —*Trans.*

It is well to make this mixture beforehand and keep it in a vessel similar to that used for soap. Every time this composition is used, it should be thoroughly stirred, for if this is not done, the soap water being heavier than the oil would run out first, and the mixture might sometimes contain no oil at all. The materials should always be heated when mixed, and this may be readily and well done if we can employ a current of steam, the combination being best effected by this method of heating.

As I have already said, after a certain length of time, the materials resume their normal conditions of density and separate into several layers :—

1st. Water charged with soap;
2d. Olive oil;
3d. Oleine.

It is indeed on this account that I have described the apparatus for dissolving soap and preparing these lubricating coatings, which in it become thoroughly mixed by means of the stirrer.

Table showing the Quantities of Composition to be used according to the Qualities of Wool.

Number of sorted wool.	Wool from, Silesia.	Saxony.	Australia.	Champagne.	Spain.	North of France.	Algeria.	Number of yarn.	Number of litres of the composition for 100 kilog. of wool.
1	Extra fine							225	12½
2	Superfine	Extra fine						180	12
3	Fine	Superfine	Extra fine					160	11½
4	Semi-fine	Fine	Superfine	Extra fine				145	11
5	Medium	Semi-fine	Fine	Superfine	Extra fine			130	10½
6	Coarse	Medium	Semi-fine	Fine	Superfine			120	10
7	Very coarse	Coarse	Medium	Semi-fine	Fine			105	9½
8		Very coarse	Coarse	Medium	Semi-fine	Extra fine		95	9
9			Very coarse	Coarse	Medium	Superfine		85	8½
10				Very coarse	Coarse	Fine	Extra fine	70	8
11					Very coarse	Semi-fine	Superfine	55	7½
12						Medium	Fine	30	7
13						Coarse	Semi-fine	25	6½
14						Very coarse	Medium	20	6
15							Coarse	15	5½
16							Very coarse	10	5

Wool absorbs oil in proportion to its fineness or dryness; a fact indicating that the material should be oiled to an extent proportionate to its quality, since the absorbing surface of fine qualities is sometimes quadruple that of coarser kinds.

Dry wool will also without difficulty absorb as great a quantity of oil as fine wool, and will become better adapted to carding. If dry and weak wools are not adequately oiled, there will inevitably be a considerable loss of substance, by waste and flyings, and the product in the end will be inferior.

The main condition then for good carding is a proper system of oiling. We must not allow the wool to become dry to the hand, and for this reason it is lubricated with a greasy liquid in order that it may be rendered supple. The operator may be easily guided by the proportions given above.

Oiling is generally performed on a pavement set in mason work.

Method of Oiling by Hand.

In oiling by hand, a layer of wool of about fifteen centimetres in thickness is spread out upon the pavement and sprinkled with half the contents of a watering pot, consisting of the proportion of composition indicated by the quality of the wool. Another layer of wool is then placed on top of the first, and receives the remaining contents of the sprinkler. The surface is then well beaten down with a wooden pitchfork, and, in order the better to enable the composition to penetrate it, the material is turned over and shaken in every direction.

If different kinds of wool are to be mixed, this should be done before the operation of oiling commences.

It is an unfortunate condition of oiling wools by hand, that they are not thoroughly and uniformly impregnated with the lubricating liquid, so that there remain parts of the wool which have not been reached, and therefore is produced the same waste as results from dry wools.

Oiling by Machinery.

In order to obviate the continual inconvenience produced by the ordinary method, I propose a system which, without being costly, produces satisfactory results; for, with this new machine, every filamentous portion of the wool is subjected to the action of the composition. (See Fig. 23, Pl. VI.)

A. Cast iron frame.
B. Cover with iron grating.
C. Apron for spreading the wool.
D. Feed rollers.
E. Drum supplied with leather plates.
F. Pulleys.
G. Funnel for receiving oil.
H. Sprinkler.
I. Steam pipe for heating the composition.

When wool is to be oiled, it is spread out on the apron in the same manner as is done in the case of the willow, the necessary quantity of composition poured into the funnel, and the stop-cock turned, so as to allow a quantity of the mixture to flow out proportionate to the amount of wool to be oiled. The wool, passing under

the sprinkler, is uniformly moistened, and passes under the feed rolls where it receives a pressure which thoroughly impregnates the wool with the lubricating material. The drum, armed with its leathers, then throws it forward forcibly, disengaging and pulling it apart.

If the wool contains impurities, these pass through a grating arranged under the drum.

It is useless to say that this method of oiling is preferable to the former. The wool is not merely well lubricated, but so divided as to be more advantageously carded.

When we insist so strongly upon the advantage of oiling by means of a composition such as we have described, it is because wools, when treated with pure oil, consume an enormous quantity of soap when afterwards scoured, and require a higher temperature than those on which the composition has been employed.

Wools, at the time of oiling, should still retain a certain amount of moisture varying from 5 to 8 per cent., for they become still dryer before being carded.

CHAPTER VIII.

Mechanical Arrangement of a Set of Cards (Breakers).

Success in carding essentially depends upon:—

1st. Proper construction of the cards.

2d. The distribution of velocities.

3d. The character of the card clothing.

4th. Lastly, a good condition and proper preservation of the card clothing.

Up to the present time, all the attempts which have been made at improvements in cards, have only resulted in rendering the clothing softer and more regular than that formerly used; but the mechanical aspect of the subject remains about the same.

It is indeed to be regretted that more attention has not been paid to the subject of velocities and the developments of the different parts of the carding machines (breakers), in regard to which much still remains to be done.

In a properly constructed breaker, the pulley, fastened by a key to the transmitting shaft, must be levelled to correspond with that fixed at the extremity of the shaft of the main cylinder.

The set of cards which I am about to describe, consists of two simple breakers, and the deductions which follow have been arrived at from a course of numerous experiments pursued by myself.

In France, as well as abroad, several different systems of carding are in practice; but, though the machines differ each from the other, the final result is about the same.

We have then six distinct systems of breakers:—

1. The simple Douglas breaker.
2. The simple breaker with angle stripper and burguard.
3. The breaker with a front cylinder.
4. The double breaker (two main cylinders).
5. The triple breaker (three main cylinders).
6. The American breaker (for carded wool).

The first engine in our arrangement is called the first breaker, from its being especially intended for the first

passage of the wool. It is built of cast iron, and has but one main cylinder with an angle stripper. (See Fig. 26, Pl. VII.)

A. Cast iron frame.
B. Feed table.
C. Feed rollers.
D. Cylinder with diamond pointed clothing.
E. Bur-guard.
F. Angle stripper.
G. Main cylinder.
H. Strippers.
I. Workers.
J. Fancy.
K. Doffer.
L. Spool.

The next machine is the second breaker. It is intended to give the wool a second carding, in order to make it more regular and terminate the work by bringing it to a high state of perfection. Its component parts are the same as those of the first breaker, with the exception of the bur-guard. (See Fig. 27, Pl. VIII.)

In order to guide the manufacturer in putting up his breakers, we give here a table of the velocities of the different parts of these machines, in relation to their diameters.

Table showing the Velocities and the Diameters of the various parts of Breakers.

Name of the revolving parts.		Number of revolutions per minute.	Diameters.
1st Breaker.			
Feed rollers . . .	C.	3	0.06 metre
Cylinder	D.	18	0.35
Bur-guard	E.	1000	0.12
Angle stripper . . .	F.	400	0.23
Main cylinder . . .	G.	80	1.50
Strippers	H.	350	0.14
Workers	I.	15	0.22
Fancy	J.	575	0.35
Doffer	K.	10	0.50
2d Breaker.			
Feed rollers . . .	C.	3	0.06
Angle stripper . . .	F.	410	0.22
Main cylinder . . .	G.	90	1.50
Strippers	H.	360	0.14
Workers	I.	17	0.22
Fancy	J.	585	0.35
Doffer	K.	11	0.50

The feed rollers rest on sliding pedestals provided with adjusting screws, and their velocity is regulated by change pinions. Next to the feed rollers comes the cylinder *D* with a diamond pointed clothing, which receives its motion from a pulley and is surmounted by a movable fluted iron roller, the fluting of which is angular, as represented in the figure. This latter roller is furnished at one end with a small pulley driven by the pulley *G*. The letter *F* represents the angle stripper with a sharp card clothing. Then follows the main cylinder, traversed by a shaft, resting upon two pedestals,

and having pulleys at both ends for communicating motion to the other portions of the machine.

The strippers rest upon supports called puppet heads. The axles of these rollers are terminated with pulleys and shoulders, in order to prevent any motion to and fro which would injure the product. These pulleys are driven by another large pulley, on the same shaft as the main cylinder.

The workers are rollers moving very slowly and having their extremities provided with hooks. They are driven by means of a Vaucanson's chain (pitch chain), which is made more or less tense at pleasure by means of a stretcher, and is generally driven by the doffer.

The fancy receives its motion directly from the belt of the compound pulley.

The doffer is a large roller, having a slow motion imparted by a pulley on the shaft of the main cylinder.

The spool receives a traverse motion while it is covered with wool, and the comb which takes the wool from the doffer is moved by an iron rod connected with a pulley at the lower part of the frame.

As will be seen then, each roller surrounding the main cylinder rests upon supports called puppet heads, which serve both to sustain them and regulate their distances apart. The puppet heads can also be raised or lowered at will, so that the intervals are rendered changeable in every direction.

Around the main cylinder of the first breaker there revolve three pairs of rollers, and four pairs for the second breaker.

As has been said before, each pair consists of a stripper and worker.

The strippers work very fast, and turn in such a manner that their teeth take hold in a direction the reverse of that of the workers, so as to strip off the wool caught in the latter. The workers, on the contrary, move slowly and present their teeth, point for point, against those of the main cylinder. Again, on the other hand, the fancy moves very fast and disposes the wool to be discharged on the doffer, which is cleared of it by the beating of the comb. Finally, the wool rolls itself up on the spool.

Impurities, such as dust and other foreign bodies, always remain in the carded material. To obviate this grave inconvenience and prevent such an injurious mixture, I have added a small sheet iron trough placed under each stripper, and intended to receive impurities and all waste set free during the operation of carding. I would recommend to manufacturers to adopt this arrangement, which I hope they will find satisfactory.

We shall not in this work speak of other breakers, which are no better than those we have just described, but which cost more and afford a less satisfactory result.

CHAPTER IX.

CARD CLOTHING.

Arrangement of the Rollers.

All the rollers of a breaker are delivered by the maker without the requisite clothing to work the wool. The process of applying this clothing is necessarily done in the carding room itself, and generally by the foreman.

When applying the clothing, the foreman should first assure himself that the rollers are perfectly cylindrical; for if they are not so, they will unavoidably have to be turned anew. This is likely to happen when the rollers are wooden; but, at the present day, they are mostly made of cast iron. An attempt has been made to use rollers of statuary pasteboard, or some other plastic substance, which it was thought would resist atmospheric influence, but these experiments only went to show that the best rollers are those of cast iron turned.

In the absence of cast iron, its place may be supplied by mahogany or old oak; but great care must be exercised not to employ green or moist wood, for under the influence of changes of temperature and especially during hot spells, the rollers will swell and crack so as to lose entirely the shape they received from the lathe.

In order to get perfectly true rollers, those are preferable which are turned upon a slide lathe or upon the frame of the breaker itself, by fastening to it a portable slide rest.

Mode of Employing the Screw Slide Rest.

For this purpose a portable slide rest is adjusted to the frame of the breaker and fastened solidly at the two ends with screws. Between the two slides of the bed plate it has an endless screw intended to direct the tool rest. This screw is terminated by a pulley about sixty centimetres ($0.^{m}60$) in diameter, and driven by a smaller pulley six centimetres ($0.^{m}06$) in diameter, fixed upon the shaft of the main cylinder. Having settled these preliminaries, and wishing to turn the main cylinder, the tool holder is armed with two sharp paring chisels of the

finest cast steel, and so adjusted that the first will pare off a shaving one millimetre ($0.^{m}001$) in thickness, and the next act as a smoother by carrying off one of only half a millimetre ($0.^{m}0005$). In this manner a roller may be turned in a single passage if its excentricity is not over one millimetre and a half ($0.^{m}0015$), for the first chisel rough hews while the second finishes. When the cylinder is very much out of centre, however, we must shave very lightly during the first passage, as we would cause inequalities on the surface of the roller if we took off too much, either by making splinters or dulling the tools, and this would give trouble in applying the clothing.

When an old cylinder is turned, the little nails which are found on its surface must be withdrawn by means of a claw, and when they resist too much, driven in with a punch.

As soon as the cylinder has been properly turned it should be sand papered, so as to obliterate any little scratches produced by the chisel, and prepare the surface for receiving the card clothing.

In turning a doffer, a pulley is fitted to one end, equal in size to that of the main cylinder; and at the other, a second pulley ten centimetres ($0.^{m}10$) in diameter, which drives the screw of the slide rest.

The workers and strippers are turned in the same manner.

As soon as the rollers are turned, they are arranged upon the frame, and a slight coat of oil is applied to exclude moisture.

As the main cylinder of the first breaker is to be covered with leather sheets, there must be made upon

its surface as many divisions as there are plates, having first carefully greased them with olive oil.

This greasing is very important; for, if it is omitted, the leather of the clothing would become dry and cracked, and the teeth rusty. In order that the oil may thoroughly penetrate the leather, the greased sheets are allowed to remain at rest for forty-eight hours, and are then applied after having been wiped off with a stiff brush, so as not to leave too much oil on their surfaces.

Mode of Applying the Card Sheets to the Main Cylinder.

In this operation we place a sheet upon one of the divisions marked on the main cylinder, having the teeth directed from us, and stretching it in the direction of its breadth, we nail it at intervals of ten centimetres ($0.^{m}10$) throughout the length of the line; after which, we fix the main cylinder in various positions by means of two Z hooks (an iron rod bent into the shape of that letter with pointed extremities).

When the main cylinder is steady, the leather is pulled from above downwards by means of a pair of pincers having grooved jaws $0.^{m}10$ wide, and by a corresponding lever and rope. By this method the leather is powerfully stretched, and may be nailed while in this condition.

The entire sheet is treated in the same manner. It only remains for us then to cover the whole surface of the main cylinder, taking care to cut off whatever leather projects beyond the division mark, and leaving between the iron and the angle of the main cylinder room enough to nail on a leather or wooden border.

Method of Applying Card Fillets to the Workers, Strippers, &c.

The fillets, having passed forty-eight hours at rest after being oiled, are very supple and elastic, and thus readily cover the rollers.

When we wish to ascertain the length of fillet necessary to cover any cylinder or roller, *we divide the length of the cylinder by the width of the fillet, then multiply the diameter by* 3.1416, *and this product by the quotient previously obtained. The last result is the length of fillet required.*

Example.—Given a doffer $0.^{m.}50$ in diameter to be covered with fillet $0.^{m.}04$ in width, the cylinder being $1.^{m.}20$ in length, what should be the length of the fillet?

$\frac{1.20}{0.04}=30$ turns of fillet.

$0.50 \times 3.14 \times 30 = 47.10$ metres, or length of the fillet.

While being wound, the fillet may stretch 50 centimetres, and as the tail pieces are narrower than the fillet, very often none will be left over.

Before winding, a tail piece is formed. This is done by placing the fillet upon a table, and marking out the place to be stripped of its teeth, which is about equal in length to the diameter of the roller, and then stripping the teeth in accordance with the line. The tool best adapted to this work is a small steel rod, bent and pointed at both ends. The end of this instrument is caught in the hooked tooth of the card, and in this way the teeth are quickly stripped off. As soon as the tail piece is made, the operator cuts off the excess of leather, and

leaves a space of a centimetre ($0.^{m}01$) next to the iron which serves for the attachment of a border.

When we are about to apply the fillet to the roller, we coil it up in a large revolving pan, so that it may unroll without twisting. At the end of the axle of the roller to be covered we fix a winch with four arms, by means of which two men turn the roller slowly, while another winds on the fillet, keeping it well to the left, so that the edges may be well joined. Behind him a fourth workman holds a flat cushion, divided in two, through which the fillet passes without creasing. At every tenth turn two nails are driven to hold the fillet in place, and the operation continues till the end is reached, when two more nails are driven and a space stripped for a tail piece, which should terminate the roller. A border is then added, which should not exceed in thickness the level of the teeth. Cylinders, workers, and strippers are treated in the same manner. In order to avoid loss of material from remnants, the fillet to be unwound is made of great length.

With the fancy we proceed rather differently; for, while the tail pieces are made in the same manner, the fillets or sheets are applied more loosely; whereas in the case of the other rollers they should be tightly stretched, and for this purpose a second roller is sometimes employed around which the fillet makes one turn.

Notwithstanding all the skill with which fillet cards may be applied, there will frequently be flattened teeth and badly joined edges. The first of these defects is remedied by straightening up the teeth with small pincers, and the second by passing the blade of a dull knife between the badly coupled edges. This last expedient

joins the teeth and brings them into line; indeed, when there are many teeth flattened, they may, from first to last, also be raised by means of a dull knife.

The Relation of Card Clothing to the Qualities of Wool.

As breakers are to be used for different qualities of wool, they must be clothed in accordance with the nature of the material to be worked. The card is to wool what a comb is to our own hair; or, in other words, coarse wool requires a coarse card, and conversely.

In order to facilitate the choice of card clothing for breakers, and to do away with any chance of error, we have constructed a table which gives at once the relation between the number of the card clothing and the corresponding qualities of wool.

Table giving the Number of Card Clothing corresponding to the various Qualities of Wool.

Cylinders to be covered.	Wools.						
	Extra fine for No. 200 yarn.	Super-fine No. 160 yarn.	Fine No. 125 yarn.	Semi-fine No. 80 yarn.	Medium No. 40 yarn.	Coarse No. 20 yarn.	Very coarse No. 10 yarn.
1st Breaker.							
Feed rollers,	No.18	No.16	No.16	No.16	No.16	No.14	No.14
Bur guard,	Diamond pointed clothing						
Angle stripper,	20	18	18	18	18	16	16
Strippers,	26	24	22	20	18	16	14
Workers,	28	26	24	22	20	18	16
Main cylinder,	26	25	22	20	18	16	14
Fancy,	30	28	26	24	22	20	18
Doffer,	30	28	26	24	22	20	18
2d Breaker.							
Feed rollers,	20	18	18	18	16	16	16
Angle stripper,	22	20	20	20	20	18	18
Strippers,	28	26	24	22	20	18	16
Workers,	30	28	26	24	22	20	18
Main cylinder,	28	26	24	22	20	18	16
Fancy,	32	30	28	26	24	22	20
Doffer,	32	30	28	26	24	22	20

The application of card clothing should be made evenly and tightly, so that the teeth may not be flattened, for in such case they would lose their power of holding the wool.

The thickness of the leather tends to strengthen the teeth, and varies according to their height and strength, as for instance:—

Thickness of leather for the fancy	0.m·0025	
" " main cylinder	0.m·004	to 0.m·005.
Height of teeth for the fancy	0.m·03	to 0.m·032.
" " main cylinder	0.m·012	to 0.m·014.

As soon as the clothing is applied to the rollers, the teeth are straightened and ground, for they are not all in the same position, and the leather in stretching yields more readily in some places than in others. Grinding is very necessary, for without this operation the wool will not be caught by the teeth in carding.

CHAPTER X.

Grinding the Cards.

All the rollers covered with card clothing are ground, with the exception of the fancy alone. The object of this operation is to equalize the teeth, render the surface of the cards perfectly cylindrical, and to give the necessary sharpness to the teeth. The sharpness of card clothing is more apparent in the finer qualities than in the coarser.

Grinding is certainly more readily performed when the roller is perfectly cylindrical, the teeth and leathers of the clothing both uniform throughout, and the emery-covered cylinder well rounded.

In order to grind either a main cylinder or a doffer, two movable pedestals are placed on the parallel sides of the frame for supporting the grinding roller, on the axle of which is fixed a pulley one fourth or one fifth the diameter of the roller itself, so that the grinding roller has four or five times as great a circumference velocity as the pulley.

To set the grinding roller in motion, a pulley is thrown into gear on the side opposite that of the one intended to drive the roller to be ground. This pulley is driven by that of the drum.

If, for instance, a doffer is to be ground, it must be made to revolve slowly, whereas the grinding roller turns very rapidly. This latter roller is then brought towards the doffer very gradually, as there is a greater loss than gain in too much haste. If we approximate the rollers too closely, the teeth to be sharpened will only break off, so that we had better never hurry the work. The two rollers work in the same direction.

Among the instruments invented to improve the operations of grinding and straightening the teeth, we must mention that of Mr. Moriceau, of Mouy. It consists of a grindstone, either of sandstone or emery, driven with a traverse motion. The cards treated by this apparatus are in no way injured, but on the contrary their teeth are better sharpened.

For grinding the cards of workers and strippers we generally use a turned cast iron cylinder, covered with one or more coats of emery and mounted on a cast iron frame, on which may also be fixed three or four of the small rollers to be ground. These workers and strippers are arranged around the grinding cylinder and the apparatus set in motion, so that several small rollers can be ground at once.

After being ground in this way, the rollers are subjected to the action of a cloth covered with fine emery powder (canvas emery).

We can easily make canvas emeries for ourselves by adopting the following plan:—

Dissolve (by the heat of a water bath) in one litre of water—

Isinglass	200 grammes.
Good glue	100 "

spread the canvas to be covered on a table, and by means of a brush paint it over with this glue; then sift fine emery powder over the glue thus spread out, equalize the surface with a smooth roller, and after drying, the material will be ready for use.

This cloth is usually mounted on two quarter circles, bound together by two parallel cross pieces.

The process of grinding is terminated by exposing the card clothing of the roller, while revolving, to the action of the canvas emery thus mounted, and then giving a last finish by the application of a leather, mounted in the same manner as the canvas emery and smeared with oil and grindstone dust.

CHAPTER XI.

Flocking the Cards.

The card clothing, after having been ground and made uniform, undergoes a further operation before being prepared to fulfil its object, the carding of wool. This operation, called flocking or stuffing, has for its aim to increase the durability of the clothing, to preserve the teeth from jarring, to prevent them from being flattened down, and the wool from becoming entangled in them.

In order to understand what would be the best method of stuffing, let us consider what takes place in carding.

The main cylinder taking the wool from the angle stripper leaves a part of it on the first worker, the teeth of which are opposed to those of the main cylinder. Just at the moment when the filaments of wool become caught in the opposing teeth, there is a slight giving or bending of both sets; but as those of the worker are the finest, and consequently present the largest surface, they retain a greater part of the wool, and though having for a moment visibly yielded, they resume their former position, undergoing, however, the same alterations in each successive passage.

The teeth, then, it will be seen, are constantly yielding, and therefore need an elastic body placed between them, to prevent them from bending, breaking, and thus producing irregularities in the clothing. This accident happens often, when the clothing is imperfectly stuffed, or when the resistance of the wool is too great for the strength of the teeth.

The less elastic the stuffing, the worse will be the result of carding, and the greater the loss of material in the operation, and we must therefore look among elastic substances unacted upon by fatty liquids, for a material susceptible of readily losing and quickly resuming its original form.

Among these elastic bodies, the shearings of fine cloths are preferred.

For some time past, card clothing of a peculiar make has been much used, and was invented by Mr. Scrive, of Lille. This clothing is already stuffed in the manufacture, and may be advantageously used in carding any

wools that are not very hard, though I believe this kind of clothing could be made coarse enough to card even hard wools.

I do not hereby intend to decry the use of leather clothing, which is undeniably of the greatest value, but only to have it understood that it is just that kind which needs stuffing.

The following is a good composition for stuffing:—

Rapeseed oil	1 kilog.
Poppyseed oil	1 "
Good shearings	3 kilogs.

The stuff and oil are incorporated together; and the mixture passed between two hand cards, so as to force the oil to penetrate every part of it.

Formerly, a stuffing of linseed oil boiled with litharge and garlic was used; but this composition was open to the objection of drying and hardening the leathers, and in that way making the teeth even more unyielding.

India rubber has been tried in vain as a substitute for the ordinary stuffing. The card clothing covered with it was found to be too easily affected by changes of temperature, so that manufacturers who require a stable compound have been obliged to abandon the use of that article.

The idea, however, is not lost, and I believe its application to the manufacture of card clothing will be made under some other form. For instance, if instead of employing India-rubber alone, to replace the leather, we should use leather covered with a layer of well vulcanized India-rubber, the two materials closely united by a same blending liquid as to form but a single fillet, this again

covered by another layer of felted wool such as Mr. Scrive always applies to his cards, and the teeth added, I think the clothing would answer the requirements of carding.

We now return to the ordinary method of stuffing. When we wish to stuff any roller, say a worker, it is placed upon a frame, with a cloth beneath it to catch the surplus material. We have also, in front of the roller and towards the workman, a semi-cylindrical trough containing the mixture for stuffing. The workman then takes some of the stuff in his hands, and presses it lightly on the card clothing, just enough to make the teeth penetrate it, and this must be done evenly over the whole surface of the roller. Then by means of a strong brush made long and broad, the stuffing is pressed down upon the leather, and a second layer applied similar to the first, which is pressed down until the surface of the stuffing reaches a level with the curvatures of the teeth.

Clothing is not used for carding until several days after being stuffed, and its drying is expedited by working the machine empty for 48 hours.

Stuffing can be done mechanically, if we wish, by spreading the prepared material upon the feed table of the breaker. The cards will then stuff themselves, but the operation is attended with such very irregular and imperfect results, as rarely to be successful.

Price List of Card Clothing already Stuffed and Made by Messrs. Scrive Brothers, Lille.

Sheets for Main cylinder and Fancy.			Fillets for large cylinders.		
Number of teeth per square centimetre.	Numbers.	Price per square centimetre.	Number of teeth per square centimetre.	Numbers.	Price per metre and a width of 60 millimetres.
28 teeth	18	fr. 0.006¼	28 teeth	18	4.15 francs
32 "	20	0.006¼	32 "	20	4.20 "
35 "	22	0.006½	35 "	22	4.20 "
40 "	24	0.006¾	40 "	24	4.40 "
45 "	26	0.007¼	45 "	26	4.80 "
50 "	28	0.008½	50 "	28	5.20 "

Fillets for doffers, workers, etc.			Fillets for doffers, workers, etc.		
Number of teeth per square centimetre.	Numbers.	Price per metre and a width of 45 millimetres.	Number of teeth per square centimetre.	Numbers.	Price per metre and a width of 50 millimetres.
30 teeth	18	3.15 francs	30 teeth	18	3.50 francs
35 "	20	3.15 "	35 "	20	3.50 "
42 "	22	3.15 "	42 "	22	3.50 "
49 "	24	3.30 "	49 "	24	3.65 "
56 "	26	3 60 "	56 "	26	4.00 "
60 "	28	3.90 "	60 "	28	4.35 "

CHAPTER XII.

CARDING.

INTERVALS BETWEEN THE ROLLERS, CARE TO BE OBSERVED IN THEIR ADJUSTMENT.

BEFORE delivering the wool to the breaker, the foreman should examine every portion, to see that it is in working order. For this purpose, he is provided with keys for regulating the intervals between the different rollers, and should always have with him a small instrument serving as a basis for their adjustment, according to the requirements of different qualities of wool. This instrument which I invented, and to which I gave the name of "card regulator," is simply composed of five small steel blades united together, the first of which is one millimetre thick, the others diminishing in thickness to a quarter of a millimetre. As it has several blades of different sizes and thickness, it will answer for regulating the intervals of several sets.

Generally, foremen are in the habit of regulating by sight, the distances which separate the rollers; but this method will never be as efficient as the measurement by an accurate instrument; for, however well trained the eye may be, it will evidently never arrive at distinguishing spaces of a half a millimeter as the regulator does.

Method of Adjusting the Intervals for Different Qualities of Wool.

Sometimes the teeth of different rollers touch each other, a defect proceeding either from too small an interval, or from the presence of hard or felted wool which, becoming entangled in the teeth, pulls them out of shape, thus occasioning inequalities in the surface of the roller. This is always bad; for, with all the care we may exercise in restoring the form of the teeth, we shall succeed imperfectly, and very often they will become straightened again, especially as we have said in the case of hard or felted wool. Under such circumstances, it will be better to card upon coarser clothing.

The causes of this accident are—

1st. Felted wools;

2d. Too small intervals;

3d. Burs in the wool;

4th. Other foreign bodies, such as crusts of bread, wood, twine, &c.

As I said in the article on grinding, inequalities in the length of the teeth disappear in regrinding the entire roller, and resume their original position.

When wool has been oiled it is ready to undergo carding. In that state it is still in locks, or at least undivided, for the filaments, being bound together by the manner of their growth, form irregular masses which must be broken up without injuring the strength of the material. In order to arrive at this result, the locks of wool are treated by such card clothing and with such intervals between the rollers as will not impair the structure of the material; and as the locks become thinner

the rollers should be brought nearer together. It is precisely upon this principle that I have constructed the "card regulator."

The different kinds of wool afford different qualities, both as regards length and strength, and must be treated in carding with intervals appropriate to their respective natures. Very coarse wools, in general, should be given greater distance between the cards than fine ones.

Among the various wools to be carded will be found some weak and shanked materials, and these, in all operations, require particular care and attention.

Fleece-bound and felted wools are treated with card clothing Nos. 14 to 22, and must be previously opened by hand or otherwise, as the felted kind soon destroys the teeth.

Short, like fine wools, are carded with fine clothing and small intervals.

In order the better to guide the operator in the adjustment of intervals, we have constructed the following table:—

Table giving the intervals between Card Rollers according to the various qualities of Wool, and the length of the Staple. (The unit for intervals is the millimetre.)

Names of the rollers.	Wools.					
	Superfine and short. Length of staple, $0.^m03$ to $0.^m05$.	Fine. Length, $0.^m05$ to $0.^m06$.	Semi-fine. Length, $0.^m06$ to $0.^m07$.	Medium. Length, $0.^m07$ to $0.^m10$.	Coarse. Length, $0.^m10$ to $0.^m13$.	Very coarse. Length, $0.^m13$ to $0.^m18$.
1st Breaker.						
Feed rollers . .	2.3	2.5	2.7	3.0	3.3	3.6
Bur guard . .	2.2	2.3	2.5	2.8	3.1	3.4
Angle stripper .	1.8	2.0	2.2	2.5	2.8	3.1
Main cylinder .	is the basis from which intervals are measured					
Strippers . . .	1.2	1.3	1.4	1.7	1.9	2.1
Workers . . .	1.1	1.2	1.3	1.6	1.8	2.0
Fancy	scarcely touches					
Doffer	1.0	1.1	1.2	1.5	1.7	1.9
2d Breaker.						
Feed rollers . .	2.2	2.4	2.6	2.9	3.2	3.5
Angle stripper .	2.0	2.2	2.4	2.6	2.8	3.1
Main cylinder .	is the basis from which intervals are measured					
Strippers . . .	1.5	1.2	1.3	1.5	1.7	2.0
Workers . . .	1.0	1.1	1.2	1.4	1.6	1.8
Fancy	scarcely touches					
Doffer	0.9	1.0	1.1	1.3	1.5	1.7

As may be seen in the foregoing table, the intervals between the rollers gradually diminish to the end of the operation; and when we compare the wool which is taken hold of by the feeders, and that which leaves the machine in slivers (ropings), the difference in the separation of the filaments and the uniformity which per-

vades the distribution will at once lead one to appreciate the necessity of accurately adjusting the cards.

The table we have just examined gives the intervals in fractions of a millimetre, but as it is rather difficult in practice to be thus accurate, an approximative estimate is obtained by means of the little regulator.

We repeat it, short wools should be carded on clothing fine enough and with intervals small enough to retain the fibres on the teeth; for if we treat short wool with coarse clothing, not being held together on leaving the feed rollers, it will be seized by the bur guard without any draught, and passed to the angle stripper which will carry it to the main cylinder. This last named cylinder being able only to retain a very small portion of it, the greater part unable to sustain itself, will fall underneath, so that that part of the wool will arrive at the doffer without being properly divided or drawn out.

On the other hand, if we treat long wools on rollers in too great proximity, we shall experience another and no less a difficulty, for the wool will be broken and leave the machine shortened, while also a great loss of material will be produced by this very breaking.

We frequently meet with irregularities in the intervals, so that either a stripper or a worker will retain all its wool.

When a stripper retains the wool taken at the expense of the adjoining worker, it is a sign that the distance from the main cylinder is too great, and the defect may be removed by approximating the stripper to the main cylinder so as to be discharged of its wool progressively.

Sometimes a worker retains its wool, and in this case it will suffice to bring the worker nearer the stripper,

which will immediately relieve it of its surplus wool, and carry it to the main cylinder.

Irregularities or cuttings are also to be observed in the ropings or slivers as they leave the breaker, in part proceeding from a faulty arrangement of the pitch chain, which should always be kept tense, or the workers will revolve by starts.

The axle of a worker, when obstructed, also produces defects.

The beatings of the doffing knife or comb should also be very regular, and in order to insure this result a system of toothed gear should be disposed on the shaft of the main cylinder, which will drive the knife so as to prevent variations of speed.

Knots, Method of Preventing and Removing Them.

In carding there are often found knots in the wool, and the foreman should be aware of the source of this defect, for a material loses much of its value in which it is found to exist to any great extent.

The causes producing knots are—

Too much moisture in the wool;

Irregularities in the surface of card clothing;

Unnecessary coarseness of card clothing;

Dulness of the teeth of the card clothing.

Faulty adjustment of intervals between the rollers;

And especially, the fancy being too far off.

When this case occurs, the fancy is brought nearer the main cylinder, but not too near, however, or by its velocity it will carry away the wool from the surface of the main cylinder.

The fancy ought to lightly touch the wool on the surface of the cards of the main cylinder, so as to smooth, straighten, and prepare it to be hooked by the doffer.

The harder and stronger the wool, the more it should be subjected to the action of the fancy; and, on the other hand, the finer it is, the less it should be so treated. For this reason fancies are made of different sizes, and it may be well to add, that though many machine builders make them, only a few make them properly.

Fancies are sometimes liable to the important defect of carrying off the wool from the main cylinder, and throwing it forcibly into the air. This imperfection is called "spitting," and results either from shortness or stiffness of the teeth, from their being too thickly set, or from the dulness of those of the main cylinder. It may be remedied by slightly flattening the teeth of the fancy, if too stiff, and sharpening those of the main cylinder, when dull.

To obtain a good and advantageous result from carding, we must have:—

1st. Perfectly oiled wool.

2d. Very little moisture in the wool.

3d. No irregularities in the teeth.

4th. Card clothing to suit the nature of the wool.

5th. Cards always well ground.

6th. A proper adjustment of the intervals, especially in the case of the fancy.

7th. The velocity of the doffer regulated to suit the product.

8th. The journals of each roller frequently oiled when in motion.

9th. A temperature of 18 to 20 degrees Centigrade.

10th. Clean belts.

We may add, however, that a temperature of 25° C. would do no harm in carding, but, on the contrary, would enable the wool, which is very elastic when warm, to be more easily drawn out.

The Operation of Carding.

In commencing this operation, flat scales with pans capable of holding a given amount of wool are placed near the table.

The wool, after oiling, is carried in baskets and placed near the machine. The workwoman begins by weighing off 300 grammes of wool, of which she then takes a good sized handful in her left hand, while with her right, she pulls it constantly in one direction, so as to make the meshes parallel and present them lengthwise to the feed rolls. By observing this method of presenting wool, we avoid loss of material, as meshes placed transversely break and occasion waste.

A good workwoman can produce more with the same material than a less skilful one. Economy is not always to be found in the employment of women at a cheap rate. Women thus employed, while only making imperfect returns, produce much waste and frequently neglect the machines.

A manufacturer should never forget that "the laborer is worthy of his hire," and not regard him as a mere instrument for the building up of his own private fortune.

During the first day, while the cards are newly stripped, every four hours' work we abstract from the 300 grammes of wool 10 grammes for the first third of the day, 6 grammes for the second, and 4 grammes for the third.

On recommencing the operation on the following day, the machine is sufficiently packed, and then continues to produce a uniform roping.

A well-constructed breaker, fed with a clean material, may easily continue at work for six days without stopping.

Formerly, a roller was used for collecting the wool as it left the cards, which rolled it out in sheets (laps); but this method is no longer employed, and we now receive the wool in cans, or preferably upon spools. It is this last plan which we here adopt, as being the most advantageous, and giving the most uniform roping at the second carding.

The first passage gives us spools, made by an apparatus with a traverse motion placed at the head of the first breaker, and these are then placed upon a creel or bobbin holder, on the rear of the second breaker, which will hold a number of them, as represented in Fig. 27, this number varying from 15 to 20. It may readily be understood, how greatly this arrangement of spools diminishes the irregularities, which were formerly attendant upon the second carding of wool.

The bur guard placed between the feed table and the angle stripper, renders great service to the card clothing by properly cleansing the impure wool. The second breaker, however, is not provided with this roller, as the wool having undergone its first carding is quite clean.

The second or finishing breaker, being supplied with spools, produces a very regular and remarkably clean roping.*

* We call *roping* the riband produced by the breakers; *sliver*, that in course of preparation in the drawing frames; and *roving*, the last drawn material previous to being spun into *yarn.—Trans.*

Quantity of Wool Carded in Twelve Hours by a set of Two Breakers, the Length of the Rollers being 1.20 *metre.*

Qualities of wool.	No. of card clothing.	Weight of carded wool.
Merino wool, No. 1, 2, 3	26 to 30	27 to 28 kilog.
Merino wool, " 4, 5, 6, 7	24 to 26	34 to 35 "
Picardy, " 1, 2, 3	24 to 26	38 to 40 "
Algerine, " 1, 2, 3	20 to 24	43 to 45 "
English, " 1, 2, 3	18 to 24	52 to 55 "

The set of breakers, employed for supplying the necessary apparatus for combed wool (worsteds), consists of seven such as those previously described.

For carded wool (called by the French carded combed), it is necessary to resort to two cardings; or, in other words, twice the number of breakers required for worsteds.

The motive power absorbed by each breaker is half a horse power.

CHAPTER XIII.

The Gill-Box.

After the second carding, the spools are collected and carried to the machine known as the gill-box. This apparatus brings the fibres of the wool into a condition of parallelism, suitable for all the subsequent operations they are to undergo.

For this purpose, several spools are arranged behind the creel or bobbin holder, and the draught is so regulated

as to give a weight of 300 to 350 grammes to every twenty metres of sliver.

This machine does not in any way resemble that used in the French process of drawing, but consists of hackle bars armed with needles, moved by means of two screws placed on the sides of the frame. The wool is first caught by three cylinders with strong round grooves, which deliver it to the moving combs. The gills, armed with two rows of pins, approach the drawing roller, and one by one sink into a groove which carries them to a second pair of screws made similarly to the others, and the sliver, after leaving the drawing roller, is rolled off into a spool by means of a traverse motion applied to the bobbin. The spools which are made upon this machine are very hard, owing to the two rollers placed upon the traversing gear. Underneath the machine, a steam pipe distributes steam to the compartments intended to receive the wool in its passage.

The wool, passing over the heated parts of the apparatus, becomes smooth, and is drawn out without catching, forming a sliver which may then be scoured, or combed in the oiled state, according to the method employed.

CHAPTER XIV.

Stripping the Cards.

Cards, after having worked several days, become loaded with a material prejudicial to the evenness of the carding. They are clogged with wool, and have to be cleared as follows:—

Two men, charged with attending to the condition of the cards, remove all the workers, strippers, &c., and place each roller upon a frame supplied with a pulley. As soon as the roller is in motion, one of the workmen passes a board covered with emery lightly over the teeth, and the resulting friction arranges them all in the same direction, so as to facilitate the removal of the packed wool. As soon as the teeth have resumed their former sharpness, the wool which is stuffed between them is stripped out with a hand card. This operation, however easy it may appear, requires a great degree of dexterity on the part of the workman.

To unclog the teeth it is not enough to rub the hand card over the roller, for evidently we should only injure the teeth without reaching all the wool kept in the card clothing. The hand card is taken in the hand, its first row of teeth nearest to the handle placed upon the teeth of the roller, and the wool pricked by raising the head of the card; a slight motion is then given it, which draws out the wool, and the roller is turned until the operation is concluded.

The stripping of the card clothing, either by means of a hand comb or card, should be so conducted that the teeth of these instruments shall follow the same direction as those of the roller. After having cleared or stripped all the cylinders of the breaker, they are treated with the emery and finishing cloths.

For stripping the teeth of a fancy, I have successfully used a comb with steel needles, twenty millimetres in length.

CHAPTER XV.

Scouring and Dressing the Slivers.

Wool, after having been carded or prepared in any other manner, is still often impregnated with various quantities of oil and other emollient matters, which it is necessary to free it from; and before spinning, it is also necessary to straighten and smooth the fibres, so as to remove their tendency to become curled or felted; in other words, to give them, by means of heat, moisture, and prolonged tension, the appearance of other textile fabrics, such as silk or cotton, as well as the general character which distinguishes combed from carded wool. All these operations are generally performed one after the other, and are all more or less expensive and tedious.

The slivers, after having been combed and prepared either by hand or machine, are scoured and rinsed separately, in twists (Fig. 30, Pl. IX.), and then dried in that condition. This is expensive, and moreover entangles the filaments after they have been combed, and sometimes felts them. In all these manipulations, the wool is exposed to damage, and never is perfectly smooth, and this is especially true of such as is only carded and destined to produce what is here called "carded—combed yarn."

By means of the machine invented by Mr. Kœchlin, all the different operations, such as scouring, rinsing, drying, and dressing, are united in a single passage

through one machine, resulting in very great economy and a superior product.

Fig. 28, Pl. IX., represents an elevation of the machine (back washer).

Fig. 29, Pl. IX., shows the passage of the slivers through the basins, and over the different cylinders and rollers.

The wool to be scoured and dressed is furnished to this machine in slivers, direct from the gill-box. In the plan of this dressing* or smoothing machine, we have represented a creel *A* with twelve spools; the twelve slivers pass at first through a basin containing a bath of soap and water, after which a pair of pressing rollers carries them to a second bath where the scouring operation is concluded.

The first bath marks 3 degrees on the saponimetre, and 50 degrees C. of heat.

The second bath marks 2 degrees on the saponimetre, and 45 degrees C. of heat.

Another pair of pressing rollers expels the water of this last bath; and then succeeds a washing or rinsing with fresh water, so as to carry off all remaining traces of soap. This water is again squeezed out by the principal pair of pressing rollers, after which the slivers pass successively around a series of eleven hollow rollers heated by steam, and upon these the wool is dried, stretched, smoothed, and thoroughly dressed, so that, on leaving this machine, the slivers may be immediately delivered to be combed or drawn.

* Extract from the *Génie Industriel,* 9th year, by Armengaud brothers.

The creel *A*, which receives the bobbins bearing the wool to be scoured, is so disposed as to carry eight, twelve, sixteen, or even a greater number of bobbins according to the width of the machine, and the size of the slivers to be passed through it. Near by is a tank *B* of tinned sheet iron, into which is poured the suds which have been used in the upper reservoir.

The slivers are drawn into this tank by the pair of pressing rollers *a*, driven by the horizontal shaft *b*.

In the interior of the tank is another pair of pressing rollers *c*, likewise driven by a wheel gear, as seen in the plate, which maintains the slivers in a horizontal position on the surface of the bath, while, at the same time, they are properly submerged by the guide roller *e*, and the floating rollers *d*.

The slivers are then carried by the pressing rollers *f*, and by the calender *g* into the second tank *C*, where there are likewise the guide rollers *h*, and the floating roller *i*. From thence the slivers pass between the first pair of pressing rollers of the soap bath *D*, and between the second pair *E*. One of these rollers is provided with hemp coilings, like those of the washing apparatus, and is subjected to a strong pressure by means of an arrangement of levers and weights in a pan *F*, placed above the rollers *D* and *E*. Between these rollers fresh water is made to run, and thence a pipe is carried which discharges its contents just above the lower roller *E*, when a thorough rinsing takes place.

G designates pulleys and driving shafts, receiving their motion by transmission, and communicating it by means of various gears to different parts of the machine, as indicated in the figure.

Six hollow copper cylinders *H* are closed at their ends with cast-iron heads, serving as journals, and provided with stuffing-boxes for the entrance and exit of steam. These cylinders are surmounted by five others of similar construction, placed above and between them, so as to hold the slivers in contact with their circumferences.

An arrangement of wheel gear serves to drive the whole series of cylinders *H*, by derivation from the main shaft through the intermediary K. As has already been said, the number of teeth in the pinions *K* progressively diminishes, so as to effect a degree of tension capable of smoothing and dressing the filaments, by giving an increasing velocity to the drying rollers.

M designates a cast iron steam-chest, into which is led a pipe for conveying the steam thither, and from which depart the pipes with elbows for introducing steam into the cylinders *H*.

The rollers *O* direct the slivers into cans placed on the floor, after they leave the smoothing rollers, and this arrangement may be employed to form spools. We will then suppose that this machine does include an apparatus for drawing and making spools.

The slivers thus obtained weigh about 300 grammes to every twenty metres, being therefore strong enough to undergo combing in the case of combing wools, and the action of the drawing frames in the case of carded combed wools.

CHAPTER XVI.

Hand Combing.

The hand combing of wool is an art of great antiquity. When it became desirable to manufacture fine, light stuffs, the necessity of some means was experienced by which wool fibres could be drawn out into a condition of perfect parallelism, in order to facilitate their conversion into fine yarn. The first and most simple idea which presented itself, was the use of a comb; and accordingly, at first, a wooden comb with a single row of teeth was used. This was followed by iron combs, still having but one row of teeth, and finally came the iron combs with two or three rows of teeth or pins.

This method was for a long while the only one in use. At the present day, it is employed in the farm houses of Picardy; and in France, there are still to be found nearly ten thousand operatives engaged in hand combing.

For certain branches of industry, such as hosiery, lace making, hand-combed wool is used in preference to all other kinds, as machine-combed wool is too straight, and yields too heavy a yarn, although not a coarse one. It is particularly important in hosiery that the yarn, when worked up, should make considerable show in proportion to its volume. This real advantage of hand-combed wool, assures a long existence to the manufacture of that article.

Machine Combing.

Repeated attempts, followed by unsuccessful results, caused it to be believed that machine combing was an impossibility. It was reserved for Dr. Ed. Cartwright, of Duncastle, Yorkshire, to prove the contrary. He took out several patents; the first in 1790, and the last in 1792. His invention consisted in a machine having a circular comb, the teeth of which were inclined towards the centre. Four cans, containing the wool prepared in slivers, fed the machine by means of an oscillating beam. Opposite the points of the teeth or needles was placed a little cylindrical comb, which combed and cleaned the wool, and it afterwards was drawn down into a can by means of rollers.

In 1827, Collier and Platt took out a patent for a new combing machine, which was worked until 1842, and during that period met with great success.

In 1842 and 1844, Donisthorpe added material improvements to the Collier and Platt machine; but it was soon afterwards succeeded by a new apparatus, which entirely revolutionized the art. This invention was the result of the genius of Joshua Heilman. He took out a patent in England and in France, in 1846, but did not introduce his machine until 1847.

With the Heilman machine, at present manufactured by Schlumberger, we avoid the inconvenience resulting from the old method.

Two holding claws gather the slivers together as they come from the feed rollers, and hold their ends until they have been combed by a roller or drum supplied with combs. The end having been combed, is then advanced,

and two other claws keep it in position, while the other end is treated in the same manner. The process is repeated several times, and then the different portions are placed in order, one after the other, so that each end covers another, thus forming a continuous combed sliver. Wool combed in this manner is in the best condition for spinning.

Heilman's machine was not long without rivals. Lister and Donisthorpe took out several patents in 1850, 1851, and 1852. These patents were based upon modifications of Heilman's; but, as the machine patented in 1851 is the only one now in use in these gentlemen's establishments, and brought by Lister into the market, we shall give it a brief description.

The apparatus for feeding the Lister combing machine consists of two screws, which move hackle-bars, having three rows of pins or needles. The wool is first fixed upon the creel, the number of spools depending upon the size of the roping produced by the breaker. A pair of feed rollers is placed in front of the combs; and over the hackle-bars or gills a brush continually drives the wool down upon the teeth. The movable piece, called the nip, which carries the wool to the great circular comb, has a motion which alternately takes the wool from the claw or holder. The claw, as soon as it has fastened upon a certain amount of wool, approaches the circular comb, and gives up its wool to the transfer comb, and *vice versa*. When the wool becomes caught in the circular comb, the large brush placed over it drives it down upon the pins. This circular comb is supplied with more or less rows of pins, the number of which varies from three to six. The circular comb, in revolving, passes in front of an appa-

ratus which draws out the wool, converting it into a sliver which is rolled off on a wooden spool. The noils, or short wool, is carried off by an oscillating knife and by rollers.

This machine accomplishes a great deal of work, four times as much as the Schlumberger combing apparatus, but, unfortunately, its price is very high.

The Schlumberger machine combs unoiled wool, and its product is much esteemed. It yields forty kilogrammes for twelve hours' work. A breaker is necessary to keep it going.

The Lister and Holden machine requires great perfection in the carded material, which must not contain knots; this is difficult to obtain in working fine wools; but the machine has the advantage over its competitor of giving an enormous return, reaching as high as 150 kilogrammes for twelve hours' work. The running of this machine presents no difficulties at all, but care should be particularly given to the preparatory carding, which is the most essential part of the operation.

We have already said that this machine generally combs oiled wool, which facilitates the passage of the knots; consequently, the ropings on leaving the breakers, must first be submitted to the gill-box, and then brought to the combing machine.

The spools, after leaving this machine, are united upon a spooling apparatus constructed much like the gill-box, and are then carried to the scouring and dressing machine (back washer).

We should not finish this chapter without mentioning the machines of Mr. Morreel, and that of Mr. Dujardin-Colette, which are employed in several woollen mills.

Mr. Brunneaux has also constructed a combing machine, which works very well and yields excellent products.

Mr. Donisthorpe, one of my correspondents writes me, is at present building a machine which, it is said, will leave all its rivals far behind. I greatly desire that his expectations may be realized, and regret that the brevity of my correspondent's communication on the subject does not allow me to give a description of the apparatus. He observes the most profound secrecy in this respect, or I should have been happy to have given an advance account of it to my readers.

Whatever the nature of the combing machine, the bobbins or spools, we have said, are carried to the spooling machine and back washer; and on leaving this latter, the slivers are subjected to processes which transform them into rovings, narrow enough to be converted into yarn of any degree of fineness.

The slivers, on leaving the spooling machine, give the weight of 320 grammes, when oiled. This weight is not always constant, as scouring and even drawing take place in the Kœchlin's back washer.

CHAPTER XVII.

PREPARATION OF WOOL FOR FRENCH SPINNING.

General Arrangements.

The locality intended to receive the preparing machines is indicated in our plan, at the end of the other rooms.

These work-rooms should be well closed, to prevent drafts from modifying the temperature, which should be as uniformly as possible at about 20 degrees of the Centigrade thermometer.

Cleanliness is also essential, and the foreman ought to require that the floors should be thoroughly scrubbed every week. There are establishments where the floors of the rooms are kept waxed, in order to be perfectly clean.

A small closet is set aside at one end of the room, where the women, on entering, deposit their shoes and put on slippers. By doing so, while walking about, they avoid soiling the waste which falls upon the floor, and the value of which, when sold, is generally increased by its cleanliness.

The evaporation which is constantly taking place in the preparing and other rooms, should be carried off by means of a fan driven by a belt from the main shaft, as this apparatus renews the air without sensibly interfering with the temperature.

Each preparatory machine is so placed that the drawing heads are opposite the creels. In this manner, the women can circulate more freely round the machines, and put on the spools without interference.

In order to understand the working of a mill, and know the causes which operate in increasing or diminishing the productiveness of the machines, a counting apparatus is attached to them, and indicates their daily product. This apparatus is easily applied, and does good service.

The number of machines varies with the quality of the wool, and may be distributed as follows:—

1st.	For coarse numbers,	seven	machines.
2d.	For medium "	eight	"
3d.	For fine "	ten	"

When we desire to work inferior qualities in making common yarns, the number of machines is smaller; and for working a fine material, greater; for the finer it is, the greater care it requires to insure regularity, whereas the common sorts are much more easily obtained after fewer operations.

The gearing of each machine should be cased, so as to protect workwomen against having their hands caught in the machinery, which has been the cause of so many accidents. This precaution has also the effect of lightening the motion; for in the case of uncovered gear, the impurities flying about in the air form with the oil a sort of paste, which wastefully absorbs power.

Finally, in each work-room there should be—

A platform scale for weighing the bobbins or spools.

A scale or quadrant for trying the slivers.

A metre with small bars at the ends, for measuring the slivers.

The assortment of machinery which should work the wool after it has been backwashed is composed as follows:—

1	Drawing	frame	4	combs,	2	spools.
1	"	"	8	"	4	"
1	"	"	12	"	6	"
1	"	"	12	"	12	"
2	"	frames	24	"	24	"
2	"	"	16	"	32	"
2	"	"	20	"	40	"

This assortment suffices to supply work for three thousand spindles.

The preparatory machines consist of a series of drawing frames of different sizes, in which the number of rollers varies; for, each machine being called upon to reduce the slivers, the numbers of cylinders ought to go on increasing in proportion to the amount of thinning the slivers have to undergo.

The drawing process has for its object to reduce the volume of a certain quantity of wool slivers, while it preserves their original weight, with the exception of a slight loss in flyings and wastings, resulting from the drawing; for, during that process, either loose filaments become detached from the slivers, or bits of wool are separated and get wound round the comb.

When this latter case occurs, the waste is carefully collected, and a skilled workwoman draws it by hand so as to repass it the next time; but the waste which falls on the machine or the floor is generally so short and poor, that it is almost impossible to subject it to that operation, and we must be satisfied to shake it up in a basket or wicker work cylinder, and employ it for carded products.

Before operating with the preparatory machines, we must first consider what work we have to do, and dispose of our material according to the special kind of wool to be converted into yarn.

We begin by—

1st. Properly lubricating the movable parts of the machine.

2d. Arranging the parchments.

3d. Regulating the intervals.

4th. Regulating the weights of the top rollers.

5th. Regulating the draught.

Levers as Applied to Preparatory Machines.

All the rollers of these machines are supplied with weights and levers, exerting a certain pressure on the top rollers. The arms of the levers are movable throughout their entire length, and their power may be modified by means of weights. Fig. 13, Pl. II., represents the arm of a lever upon which notches have been cut for holding the weight in position, as the sizes of the slivers cause them to oscillate during the operation of drawing.

It appeared to me important to determine the approximative weights on the levers of all preparatory machines, corresponding to the different qualities wool to be treated; and the reader will accordingly find a table following, wherein the results of these calculations are given.

Table showing the Weights and Arms of Lever which are in Equilibrium with a given Power.

Power or pressure in kilogrammes.	Distance from the fulcrum to the power.	Length of lever from the fulcrum to the weight.	Weight in kilogrammes producing equilibrium.	Power or pressure in kilogrammes.	Distance from the fulcrum to the power.	Length of lever from the fulcrum to the weight.	Weight in kilogrammes producing equilibrium.
5	$0^m.14$	$0^m.70$	1	35	$0^m.14$	$0^m.70$	7
	0.12	0.60			0.12	0.60	
	0.10	0.50			0.10	0.50	
	0.08	0.40			0.08	0.40	
	0.06	0.30			0.06	0.30	
10	0.14	0 70	2	40	0.14	0.70	8
	0.12	0.60			0.12	0.60	
	0.10	0.50			0.10	0.50	
	0.08	0.40			0.08	0.40	
	0.06	0.30			0.06	0.30	
15	0.14	0.70	3	45	0.14	0.70	9
	0.12	0.60			0.12	0.60	
	0.10	0.50			0.10	0.50	
	0.08	0.40			0.08	0.40	
	0 06	0.30			0.06	0.30	
20	0.14	0.70	4	50	0.14	0.70	10
	0.12	0.60			0.12	0.60	
	0.10	0.50			0.10	0.50	
	0.08	0.40			0.08	0.40	
	0.06	0.30			0.06	0.30	
25	0.14	0.70	5	55	0.14	0.70	11
	0.12	0.60			0.12	0.60	
	0.10	0.50			0.10	0.50	
	0 08	0.40			0.08	0.40	
	0.06	0.30			0.06	0.30	
30	0.14	0.70	6	60	0.14	0.70	12
	0.12	0.60			0.12	0.60	
	0.10	0.50			0.10	0.50	
	0.08	0.40			0.08	0.40	
	0.06	0.30			0.06	0.30	

In order to determine the pressure for any given preparatory machine, it will be found sufficient to consult the preceding table, where the power is given in accordance with the length of the arms of the levers.

Example 1.—If it is desired to obtain a pressure of 30 kilogrammes, we look for the power 30 in the column of powers, and the distance to be maintained between the fulcrum and the power is indicated by one of the five figures contained in the column of distances between the fulcrum and the power. At the same time, we suspend a weight of six kilogrammes at one of the points indicated in the column of the arms of levers, which is found in the first column opposite the figure chosen.

Example 2.—We wish to obtain a pressure of 40 kilogrammes, by using a weight of 8 kilogrammes.

Distance from the fulcrum to the power	$0.^{m}06$
Distance from the fulcrum to the weight	$0.^{m}30$

By this means, it will always be easy to tell the necessary pressure at a glance, without calculation. The following observation, however, should be taken into consideration, viz., that the greater the volume of the sliver, the more the pressure should be increased, and conversely for the finer kinds.

As far as concerns the different qualities of wool, we must be guided by the nature of the material; for all wools not being of the same nature, they will offer a greater or a less degree of resistance, and therefore, be more or less liable to be crushed under pressure and break.

Wools of coarse staple can, without inconvenience, be subjected to strong pressure; whereas finer wools, having filaments of smaller diameter, and being by nature softer, can only undergo pressures proportionate to their power of resistance. These pressures are much smaller than those which may be withstood by wools of a coarser staple.

The preceding table only indicates powers or pressures obtained through the levers, and I have added the following table, which will guide the operator in distributing these pressures to the various preparatory machines, according to the quality of the wool under treatment.

Table of the Pressures to be Applied to the various Qualities of Wool on the Drawing Frames.

Preparatory machine.	Wools. Pressures in kilogrammes.						Remarks.
	Extra fine.	Fine.	Semi-fine.	Medium.	Coarse.	Very coarse.	
1st Drawing frame,	130	140	150	160	170	180	
2d Drawing frame,	105	110	115	120	125	130	3d Category.
3d Drawing frame,	95	100	105	110	115	120	
4th Drawing frame,	85	90	95	100	105	110	Hard wools.
5th Drawing frame,	75	80	85	90	100	105	
6th Drawing frame,	50	55	60	65	70	75	
7th Drawing frame,	40	45	50	55	60	65	
1st Drawing frame,	125	135	145	155	165	175	
2d Drawing frame,	100	105	110	115	120	125	2d Category.
3d Drawing frame,	90	95	100	105	110	115	
4th Drawing frame,	80	85	90	95	100	105	Common wools.
5th Drawing frame,	60	65	70	75	80	85	
6th Drawing frame,	55	60	65	70	75	80	
7th Drawing frame,	45	50	55	60	65	70	
8th Drawing frame,	35	40	45	50	55	60	
1st Drawing frame,	120	130	140	150	160	170	
2d Drawing frame,	100	105	110	115	120	125	1st Category.
3d Drawing frame,	90	95	100	105	110	115	
4th Drawing frame,	80	85	90	95	100	105	Very fine and soft
5th Drawing frame,	70	75	80	85	90	95	wools.
6th Drawing frame,	50	55	60	65	70	75	
7th Drawing frame,	40	45	50	55	66	65	
8th Drawing frame,	30	35	40	45	50	55	
9th Drawing frame,	25	30	35	40	45	50	

This table is based upon my experience of the pressures from which I have obtained the best results.

When we desire to make use of this table, we first ascertain the nature of the wool to be drawn out, and then arrange the pressures according to the figures indicated. This may be done in an instant, and for greater facility's sake we mark the power upon each division of the lever, which allows us, when we begin new operations, to change the divisions without difficulty.

Example 1.—Wishing to work upon extra fine wool, and convert it into fine numbers, we look for the first category of fine wools, and we arrange the different preparatory machines according to the first column, which indicates extra-fine wools. For instance, the pressure at the first drawing frame (4 combs, 2 spools) will be 120 kilogrammes.

Example 2.—If we wish to treat an extra coarse kind of the second category, and make it into coarse numbers, we find that the sixth column of this class indicates a pressure of 175 kilogrammes at the first drawing frame.

The same method should be followed for all qualities and all machines.

Not only can fine wools not undergo strong pressures, but poor wools of weak staple are in the same predicament.

In order that the pressure should be well exercised upon the filaments, it is necessary that the rollers should be perfectly cylindrical, and that the leather covering their surfaces be smooth. There will come a time when the leather will be found worn out just at the place where the pressure is exerted. Whenever this defect presents itself, it should be changed as soon as possi-

ble; for, however strong the pressure, it no longer acts efficaciously.

Weighted Top Rollers.

Before paying attention to the passage of the wool through the preparatory machines, we must indicate the active causes affecting the operation; for, in order thoroughly to understand the principle governing the working of these machines, and get the best and largest product possible, we must of necessity know the obstacles which we are liable to meet with, and by ascertaining their causes, endeavor to overcome them.

The mode of applying the pressure is about the same in all preparatory machines, excepting the differences in power and diameter of the weighted top rollers.

Every frame, intended for the drawing out of slivers of wool, is supplied with top rollers. The pressure or power acts upon two rollers, and, as we have said before, is variable. A pair of top rollers is united by an iron axle, the central portion of which is turned to receive the brasses for the saddle of the lever; the two extremities are also turned and revolve in movable blocks sliding upon guiding grooves. These blocks are of composition (bronze), and surmounted with little wooden caps (top clearers), which serve as cleaners to the top rollers. When we wish to oil the bearings, we raise these caps and pour the oil into holes made in the brasses for this purpose, and the same thing is done in oiling the bearings of the levers. In order that the pressure may be properly exerted, the saddles are supplied with pillow blocks of bronze, broad enough to prevent oscillation.

The top rollers are wooden, and traversed by an iron axle, as has been said before; after being turned they are covered with calfskin.

The diameter of top rollers varies according to the machines to which they are to be adapted. Thus, for the first drawing frame, we use rollers 12 to 15 centimetres in diameter. Large diameters never do any harm for the top rollers, especially those behind the drawing roller, but hold the wool better. Many frames are mounted with cast iron rollers, the use of which, we think, should be discarded, for they do not seem to act with the same regularity as the wooden ones. It is true that these latter wear out quickly, but they scarcely produce any barbs (roller waste) on the surface of the slivers, which is due to the fact of their being more elastic than the cast iron ones, even though these are covered with leather.

The top rollers diminish in diameter down to the last drawing frame, the diameter of which, in our assortment, is generally $0.^{m}07$.

What has just been said applies exclusively to top rollers covered with leather.

The top rollers intended to accomplish the final drawing are distributed in the same manner; but, instead of leather, they are covered with a felted stuff glued upon the wood. After this felt has been applied, four cuts are made with a saw, in which are fixed sheets of parchment, broad enough to cover the packing washers of the combs, and yet not hook on to the teeth, as that would occasion irregularities in the roving.

After awhile, the felts glued on the rollers become loose. This happens oftenest when they have been glued

with glue from Givet. One of the best processes for fixing the cloth to the surface of the rollers is as follows :—

To 2 litres of boiling water add—

Isinglass	300 grammes.
Glue	50 "

After completing this solution, smear with it the roller and the cloth, then apply the latter to the whole surface of the former, roll it on a board to produce adhesion, and then dry it.

The felts glued in this manner are very firm, do not loosen, and wear a great while; still we must not abuse them, for a roller overworked produces a bad result.

The leathers are glued in the same way, at least those of the throstle frame; for the leathers of the preparatory machines are generally separated from the rollers by a thin felt, although sometimes glued on directly.

The pressures for each batch of wool to be worked, are distributed according to the material. They should not be too great, or they will destroy the bearings and absorb a useless amount of power, while the wool would not be the better treated. At the same time, we ought to remark that too small a pressure may result in a bad product.

Caps or Top Clearers.

The top clearers render great service by retaining the dirt carried off by the top rollers. They should be cleaned every now and then, and often, indeed, if the wool is badly scoured.

After long wear, there accumulates under the top

clearers a mass of small wool, fibres detached from the slivers, and mixed with impurities. The woman in charge of the machine should take care that this accumulation does not become too great, for there would inevitably be portions detached, which would be carried on with the slivers, and do damage by soiling and making them irregular.

This waste is kept apart, so as not to be mixed with that of the drawing process.

The under part of these clearers is covered with a coarse felted cloth, glued on in the same manner as in the case of the top rollers. These clearers soil rapidly, and, in that event, should be renewed as soon as they may appear no longer fit for service. Many machines are provided with clearers placed under the fluted rollers, and appear to give satisfaction to the manufacturers who use them. They prevent the formation of barbs.

We repeat, in dismissing the subject, that the top clearers must be kept in order, as they are receptacles for impurities.

Oiling the Machinery.

The length of time during which the machinery of a spinning mill will work, essentially depends upon the oiling of the parts which are kept in motion throughout the day. Many manufacturers have ruined their machinery by neglect in this respect, so that it is really very poor economy to be too sparing of the oil necessary to the working of our machines.

Every workwoman should have a long-necked oil-can,

made so as not to spill if it falls on the floor, as will very often happen.

Before throwing the machine into gear, the woman begins by oiling every movable part of it, such as the rods of the rubbers, the receiving gear, the excentrics, all the axles of the cylinders and top rollers, the gearing, and the sliding fixtures. These parts of the machinery having a more accelerated motion, are oiled twice a day; whereas those which have only a low velocity, need not be lubricated oftener than once in two days. In the case of the axle bearings of the top rollers, a little purified suet is added, in order to prevent heating and gumming.

I have said all that is necessary, in regard to the best substances for oiling, in the article on friction, where the reader will find useful information on this entire subject.

Intervals.

All the machines are constructed so that the intervals between their rollers may be varied at will according to the requirements of the case. It is an important principle in this matter, that—

*According to the length of the staple should be the intervals between the heads of rollers.**

In other words, that the longer the staple, the greater should be the intervals, and conversely.

It is evident, that if short wool is drawn between rollers too far apart, variations will occur in the structure of the sliver, so that sometimes it will come out very thick, and thus occasion a thinness of other portions, as there

* M. Alcan, Professor at the *Conservatoire des Arts et Métiers.*

can be no thickening of one part that does not take place at the expense of another; what is in excess in one place will be deficient in another, and this is a certain evidence that the interval between the rollers is out of proportion.

The intervals vary not merely in proportion to the length of the staple, but must be changed whenever there is a variation in the volume of the slivers; thus, the coarser the slivers, the further apart must the rollers be. Let us give an example of what we state.

If we arrange the rollers of the first drawing frame with the same intervals as those of the last one, the sliver will inevitably be broken, as there will not be room enough for it to expand. There has therefore to be an arrangement of intervals, regulated according to the volume of the slivers to be drawn out, and the length of the staple.

If a short wool were treated with rollers at disproportionate intervals, the wool, not being properly guided, would follow the caprice of its conformation and produce a sliver, the regularity of which would be spoiled by many cuttings.

It is to obviate these defects that the preparatory machines are provided with racks for changing and varying the intervals.

We frequently object to this changing, which however is really less troublesome than it seems; but, I believe, we always lose by waste more than we otherwise gain. I would remark, nevertheless, that when an establishment possesses several sets of machines, many qualities of wool can readily be worked, with scarcely any change in the adjustment of the intervals. Manufactories of fine wool

are of this character, but those working qualities from No. 10 to No. 80 are obliged to vary the intervals frequently; and in this case, several lots of the same quality are put through the machine in succession. In this way, there is less trouble.

To effect a change in the intervals, the rollers are either advanced or withdrawn by means of a key, which moves the car of the rack; while with callipers the space intervening between the rollers is measured.

The intervals should diminish gradually, from the entrance of the trumpet or funnel to the last drawing roller.

For the better guidance of operators, I have prepared the following table:—

Table showing the Intervals in Preparatory Machines, according to the quality of the Wool and the length of the Staple.

The dimensions are given in centimetres.

Preparatory machines.	Wool.						
	Extra fine and short. Length of staple, 3 to 4 for yarn No. 100 to 160.	Fine and short. Length 4 to 6, yarn No. 100 to 140.	Semi-fine. Length 6 to 7, yarn No. 60 to 120.	Medium. Length 6 to 8, yarn No. 40 to 60.	Common. Length 8 to 10, yarn No. 30 to 40.	Common. Length 10 to 12, yarn No. 25 to 30.	Coarse. Length 12 to 15, yarn No. 10 to 25.
1st Drawing frame	16 to 18	18 to 20	20 to 22	22 to 24	23 to 25	25 to 27	27 to 30
2d Drawing frame	14 16	15 17	16 18	17 19	19 20	20 21	20 22
3d Drawing frame	13 14	13 14	13 15	14 16	15 17	17 18	19 20
4th Drawing frame	12 14	12 14	13 14	14 16	15 17	16 17	18 20
5th Drawing frame	10 12	11 13	12 13	13 14	14 15	15 16	17 18
6th Drawing frame	8 10	9 11	10 11	11 12	12 13	13 14	16 17
7th Drawing frame	8 10	9 11	10 11	11 12	12 13	13 14	15 16
Spinning mule	8 10	9 11	10 11	11 12	12 13	13 14	15 16

The interval is generally regulated by taking some of the wool filaments, and measuring them upon a scale which indicates their respective lengths.

The intervals are counted, from the comb to the feed roller. The interval between the comb and the drawing roller is about 9 or 10 centimetres, measured from the top of the comb, or porcupine, to the point of contact with the drawing roller. Practice alone, however, will guide the operator in the management of these machines, providing he consults the tables already given, and notes the different observations which they contain.

Yarn may indeed be spun by guess work, but it will never be worth as much as that which is produced by a man who is practically and theoretically a master of the art.

Parchments.

Parchment is made from sheep-skins, and used to cover all the front drawing rollers, and those of the spinning frames.

For several years past, artificial parchment has been made with paper pulp, converted for the purpose into a hard material which, in many cases, takes the place of true parchment. This composition is one-third the cost of animal parchment, but is less durable, and, when worn out, produces bad results and becomes entirely useless; whereas animal parchment lasts four times as long, when the method we shall describe is followed.

The parchment is cut up into bands for covering the top rollers. In some establishments, these rollers are covered with two bands, others employ four; both methods are good. As I have already said, the four cuts made in the rollers receive four bands, the extremity of each of which touches the junction. In order to make

these parchments firm, washers are screwed on to their sides, and in this manner they are kept from varying.

Parchments are divided into qualities, according to the wools to be treated, and according to their thicknesses. For this object, we weigh off a certain number of sheets, say 30, which number weighing one kilogramme, forms No. 1.

No. 2.—2	kilogrammes for	30 sheets.
" 3.—3	"	"
" 4.—4	"	"
" 5.—5	"	"
" 6.—6	"	" *

The numbers or qualities of parchments are distributed in the following manner:—

For the	1st	drawing frame,	No 5.
" "	3d	" "	" 4.
" "	other	" frames,	" 3.
" "	mule,		" 2.

It should be understood that these numbers can only be applied as far as the qualities of wool will allow, which can alone be determined by the operator.

Sheep-skin parchments last on the last drawing frames for several days, sometimes twelve, especially if the wools have been well scoured, but it is important not to allow those of the finishing (roving) frame to be used too long. They should be changed once a week. The first day, the number of the sliver slightly varies, but ceases to do so on the second.

* We miss here the width and length of the sheets, unless parchment sheets are always of the same dimensions.—*Trans.*

Frequently, after a certain time, the parchments become charged with a greasy substance, proceeding principally from the fatty and soapy matters contained in the wool; but we should not, on that account, suppose that they are to be removed, for they are still good, and after undergoing a slight operation, may be used for drawing. It will suffice to dip a tooth-brush into a liquid which I have composed for the purpose, and lightly rub the dirty part, which is afterwards to be wiped with a sponge. By following this course, we shall always succeed in removing fatty matters which have escaped other agents, and thus double and treble the durability of the parchments.

Circular Combs (Porcupines).

The combs employed in the preparatory machines are cylindrical, and bristling with needles or pins over their surface. Hence their name of Porcupine.

The diameters of these combs vary with the machines to which they are to be adapted; thus, the more bulky the slivers, the larger is the diameter of the combs, and conversely.

Each comb is opposite the drawing roller, and is attached to a shaft driven by means of wheel gear. This shaft is movable, so that it may be advanced towards or withdrawn from the drawing roller, according to the motion intended to be given it.

The greater or less number of pins in a comb, is intended to allow the qualities of wool to be varied, and thus prevent the bending or breaking of the filaments. This number increases as the qualities become finer, and the

slivers more slender; for it is evident that if we should subject a light sliver to a comb, the pins or needles of which should be too few in number, it would not be retained by them, and thus would produce a bad result.

We say therefore, that the coarser and bulkier the slivers, the coarser should be the combs, and the longer the pins.

Each comb has a socket at each end traversed by several screws, by which it is fixed upon the comb shaft.

We have prepared the following table, which will be of great use to operators, by indicating the method they are to follow, in varying the combs according to the materials and numbers which they have to make.

Table indicating the Diameter, Length, and Number of Pins in one Row, for Combs employed in Drawing Frames, and for the Number of Yarn to be produced.

(All the dimensions are stated in millimetres.)

Preparatory machines.	Number of the yarn.	Diameter measured at the base of the pins.	Length of the comb.	Number of pins in one row.	Number of rows.
1st Drawing frame,		100	100	30	42
2d Drawing frame,		65	65	30	48
3d Drawing frame,	No.	60	60	30	36
4th Drawing frame,	10 to 20	45	60	45	30
5th Drawing frame,		40	60	45	32
6th Drawing frame,		40	50	40	32
7th Drawing frame,		40	50	40	34
1st Drawing frame,		90	100	33	48
2d Drawing frame,		60	90	30	36
3d Drawing frame,	No.	55	80	50	30
4th Drawing frame,	20 to 40	40	60	45	32
5th Drawing frame,		40	50	40	32
6th Drawing frame,		40	45	50	36
7th Drawing frame,		35	40	50	36
1st Drawing frame,		80	100	35	50
2d Drawing frame,		55	80	50	30
3d Drawing frame,	No.	50	65	40	30
4th Drawing frame,	40 to 60	40	50	40	32
5th Drawing frame,		40	45	50	36
6th Drawing frame,		35	50	40	36
7th Drawing frame,		32	50	40	36
1st Drawing frame,		70	100	38	52
2d Drawing frame,		50	65	40	30
3d Drawing frame,	No.	50	60	40	32
4th Drawing frame,	60 to 90	35	50	40	36
5th Drawing frame,		35	45	40	36
6th Drawing frame,		35	40	35	32
7th Drawing frame,		35	35	35	32
1st Drawing frame,		70	100	40	52
2d Drawing frame,		50	60	30	32
3d Drawing frame,		50	60	30	32
4th Drawing frame,	No.	35	40	35	32
5th Drawing frame,	90 to 120	35	35	30	30
6th Drawing frame,		30	35	30	26
7th Drawing frame,		30	33	30	26
8th Drawing frame,		30	32	30	26
1st Drawing frame,		90	100	40	52
2d Drawing frame,		50	60	30	32
3d Drawing frame,	No.	50	60	30	32
4th Drawing frame,	120	35	40	35	32
5th Drawing frame,	to	35	35	30	30
6th Drawing frame,	180	30	35	30	26
7th Drawing frame,		30	34	30	25
8th Drawing frame,		30	33	30	24
9th Drawing frame,		28	32	30	24

Movement of the Combs.

The combs revolve more slowly than the drawing rollers. The rate of motion should be calculated so that the combs should retain only the wool engaged in their pins, which should be sharp pointed, and present themselves so as to enter the sliver readily.

Combs are therefore regulated by the width of the sliver; for the thinner the sliver is, the more elongated it becomes, and thus requires a smaller comb with finer and closer pins. These pins or needles are of steel, and should be so arranged that their points may somewhat incline in a direction the reverse of that in which the drawing takes place, so as to hold the wool.

They must be occasionally cleared, especially when charged with dust and waste, as these impurities prevent uniformity in the result of the drawing, by occupying the space which might be filled with filaments lodged there during the process.

It is impossible to establish practical rules for the working of the combs. The foreman in charge of this operation must consult the nature of his wool, to ascertain whether it will stand a strong tension, and if it can, the motion of the combs is retarded.

The motion is accelerated by withdrawing two or three teeth from the change pinion, or, in other words, by replacing the first by a second, bearing a smaller number of teeth. One tooth often causes irregularities (barbs). As the combs grow old, a tooth is withdrawn from the change pinion; for the diameter of the comb is lessened by the wearing away of the pins, producing a very perceptible and injurious effect.

Position of the Combs.

The proper position of the combs is, without doubt, one of the principal conditions of good work. Some of the irregularities in the product and other defects proceed from the motion of the comb in a bad position.

I have for a long time adopted with advantage the following system for carefully regulating the rollers of a drawing frame:—

I attach a rule to the drawing and feed rollers; upon this rule I apply my level,* and dispose the slope so that it shall mark 2 centimetres of inclination towards the drawing roller. Then I grade the points of the comb 2 centimetres above the level thus found. This is a good position, for, if the combs were lower than this, the slivers, not being stretched enough, would not sink into them; and if, on the other hand, they were too high, the slivers would be cut, especially if the wool happened to be of a short staple.

Long wools may be worked at three centimetres above the level.

The shorter the wool is, the nearer must the comb approach the drawing roller. It must then be somewhat lowered, as otherwise the wool will be cut, and experience too great a difficulty in passing over the comb.

When a pin is bent, it should be straightened at once, and when worn out, quickly replaced; for we

* A very sensitive index level, marking as low as the tenth of a millimetre, giving both the vertical and horizontal direction, and hence the inclination.

cannot produce good work with combs, the pins of which no longer enter the wool.

Rotary Rubbers.

The rotary rubbers receive their motion directly from the excentrics *H*, represented in Fig. 33, Plate XI. This method of driving them, which is due to Mr. Brunneaux, Senior, is much softer than that obtained from cranks, or especially the helicoid cams, which I have had occasion to use.

This excellent invention of rubbers has greatly contributed to the progress made in the art of spinning within the past few years.

The iron racks supporting the wooden tables are often weak, and produce an oscillation prejudicial to the work.

In general, the tables do not need to have play, as some persons have presupposed; on the contrary, it is a means of increasing the size of the leathers. When the table is slightly convex around the edges, it will prevent the leathers from protruding.

The rate of motion of the rubbers is regulated in the same manner as that of the drawing roller, unless the leathers are too loose upon the tables. The sliver is often lengthened between the leathers, and this denotes a bad adjustment; the sliver should not be subject to any elongation, nor yet should it be free to float between the rubbers, as it would produce a soft spool, but should be rolled out properly.

If the leathers should be too loose, we may add a tooth

to the pinion driving the rubbers, which will compensate for the loss of velocity experienced by the rubbers.

Spool Drums.

Each of the last drawing frames has on its forepart a row of spool drums, each of which is intended to receive a spool.

These drums are set in motion by a pinion fixed to the extremity of an iron shaft, which at the same time produces a traverse motion.

The drums are of wood, covered by a coating of varnish or paint, to render the surface coarser and less slippery.

Small cast-iron slides are attached to this movable frame, and between each of them is placed a spool drum.

The circumference velocity of these drums is in proportion to the adequacy of the rubbers; but, as the spool must be made without elongation of the wool, the tension effected by them must not be too great.

Hard Spools.

A good means for obtaining hard and firm spools, is to use a heavier iron rod than is usually employed to pass through the bobbin. We thus obtain an adequate pressure.

The same result may be obtained by bringing the funnel nearer the spool drums. These methods are infallible for procuring spools of the requisite hardness.

Sometimes the drums do not give hard spools, and, in that case, the foremen have a habit of adding leather to

their surfaces, in order to increase their circumference velocity; but this process is imperfect, and we recommend the following:—

On Saturday evening lay on these spool drums a coating of paint composed of:—

Spirits of turpentine . . .	100 grammes.
Linseed oil (boiled with litharge)	50 "
Venice turpentine . . .	50 "
Black oil varnish . . .	50 "
	250 grammes.

FIRST PASSAGE.

1st Drawing Frame—4 Combs, 2 Spools.

This process has for its object to modify the structure of the filaments, and make regular the slivers which have left the back washer, or have just been combed without being oiled.

This becomes particularly necessary, when the slivers have been badly drawn by the back-washer; that is to say, when much tangled, and too coarse or bulky. It must be understood that wools which have not been combed, as, for instance, carded wools, are never as straight as those which have been. Still, well-carded and dressed wools, subjected to the pressure of the gill-box without steam, are excellent. No lumps are observable in them, and they resemble closely combed wools.

I would remark that the latter give, in spinning, finer yarns than the former. There are branches of industry which require cheap and bulky wools, and for such pur-

poses, those kinds of carded (in French, carded-combed) wools are well suited, for they may be made of materials unfit for combing, and often even of waste.

The wools which have been well treated on the cards or other machines, in order to give them the required perfection, are then susceptible of undergoing other modifications with a view to rendering them fit for regular spinning.

Both combed and carded wools are treated in the same manner on the preparatory machines.

Generally, carded (in French, carded-combed) wools are employed for producing the lower numbers of yarn, which vary from No. 6 to No. 50. It is not customary to go above this, and the yarns of higher numbers are made from combed wool.

Each manufacturer then makes use of special products; some employ mixed or combed-carded yarns, others combed yarns, &c.

The slivers obtained by combing the oiled material are scoured, and on leaving the back-washer are dry and drawn out; their weight indicated upon the steelyard is about 500 grammes for 50 metres. These slivers not being of an uniform weight, it becomes necessary to sample them, in order to remain assured of their regularity.

The scale which, it will be recollected, forms part of the apparatus of the preparing room, receives the bobbins or spools made at the back washing machine, or rather at the gill-box, which is provided with a counting apparatus which determines the length in metres. Thus we have a uniform length, but as the weight varies, notwithstanding all the care we may bring to bear upon these preliminary operations, it becomes necessary to regulate the preparations by doubling and weighing.

We shall call "preparations" the ropings, slivers, rovings, &c., passing through the various preparatory machines, in order to become "prepared" to go to the spinning frames.

Thus, before subjecting the spools to the first drawing frame, a description of which we give further on, it is necessary to weigh them, one by one, upon the scales at their first passage, and to mark their weight.

These spools generally weigh from five to six kilogrammes.

Fig. 32, Pl. X., represents a first drawing frame, as constructed by Mr. Dubrule, of Tourcoing (Nord), and having at the back part a creel.

A. Cast iron frame.
B. Extension to hold the creel.
C. Pulleys receiving motion.
D. Wheel gear of the first drawing roller.
E. Wheel gear of the second and last drawing roller.
F. Spools to be drawn out.
G. Feed roller.
H. Top roller of the feed roller G.
I. Combs.
J. Top rollers of the first drawing set.
K. Top rollers of the feed rollers G'.
L. Spool of drawn wool.
M. Belt shifter rod.

As we have said, the spools are weighed on the scale before being submitted to the action of the machine. This is done to each successively, and they are then placed in boxes behind the creel, so that the workwoman may not go far to find them.

Each box represents a difference of 100 grammes; that is to say, the spools among which there exist a difference of 100 grammes in weight, are separated and distributed to the drawing frame according to their weights.

In fact, in order to produce a uniform sliver, it is necessary that the heavy spools should be incorporated with the lighter ones, so that a mean weight may be obtained, and care is taken, that in sorting a batch to be mounted, its weight should be uniform, though the weights of the single spools may differ.

Take a first mounting composed of 8 spools.

First mounting.

1	spool of	5	kilo.	200	grammes	21 kilogrammes.
1	"	5	"	100	"	
1	"	5	"	400	"	
1	"	5	"	300	"	
		21.		000		

1	spool of	5	kilo.	000	grammes	21 kilogrammes.
1	"	5	"	500	"	
1	"	5	"	400	"	
1	"	5	"	100	"	

Second mounting.

1	spool of	4.900	kilo.	21 kilogrammes.
1	"	5.000	"	
1	"	6.000	"	
1	"	5.100	"	
		21.000		

1 spool of	5.800 kilo.		21 kilogrammes.
1 "	5.000 "		
1 "	5.100 "		
1 "	5.100 "		
	21.000		

As may be seen by these combinations, the mountings may be varied to infinity. If, by chance, a spool should weigh more than 6 kilogrammes, it is placed with one weighing less than 5 kilogrammes; and in this manner we shall always be sure of uniform slivers, excepting in the case of a single strand, which rarely occurs during the first passage through the drawing frame.

One of the essential conditions for preparing wool in the machines which we are now speaking of, is to allow the spools, whether coming from the back washer or from being combed without oiling, to rest for several days in a storeroom where light penetrates with difficulty, so that they may return to such a hygrometric condition that the wool shall be soft to the touch, while, at the same time, however, it is very important that it should not be moist. It is then submitted to the first drawing process.

The creel carries eight bobbins. Fig. 32, Pl. X, represents only a half mounting which, however, is sufficient to show the working of the machine, and the results it affords.

Mode of Operation of the First Drawing Frame.

The bobbins are placed upright upon a wooden axle, the lower part of which receives the wooden hollow spool, and having iron points at each end which rest in steps.

Each pair of slivers pass under the rollers *H*, through the combs *I*, and are drawn out by the roller *J*; after that, the two slivers form only one. The draught going on alongside acts in the same manner. In front of the drawing rollers are placed small iron guides, to keep the sliver from deviating from its position, either during or after the draught. The two slivers joined together are then passed under the top rollers *K*, then united and slightly drawn out between the rollers *G′*, whence the doubled sliver passes through the comb *I*, and is drawn out by the top roller *J*.

The sliver then passes into a movable funnel, the working of which is not shown in the plate.

The sliver, on leaving this funnel, is rolled off on a wooden tube and forms a spool, the winding of which is regulated by a traverse motion. As soon as this spool has reached the point of its constant length, the regulator or indicator stops the machine; the workwoman then takes off the spools and begins afresh.

Draughts and their Calculation.

The draught of the first drawing frame is generally from 1 to 10, and even more, for the operation is repeated several times. The first time on two of the combs, and the second time on the last comb.

The draught is effected gradually on the first, as well as upon the other drawing frames.

In the mode of working which we propose to follow, we shall represent the first draught by 3.6, and consequently the second by 2.4, so as to have a total of 6;

and we shall suppose that we are treating a combed Picardy wool, in order to make a yarn No. 40.

Analysis of the Draught on the First Drawing Frame.

In any one machine all the rollers are of the same diameter, and we therefore do not need to take their diameters into calculation, unless they should happen to be unequal.

The circumference velocities of the drawing rollers goes on increasing by means of a pinion smaller than that fitted to the feed rollers, whence we conclude that *The product of the driving wheels divided by that of the driven, gives us the draught as the quotient.*

Example.—Let us suppose that this first frame has a drawing set upon its fore part.

Calculation of the First Draught.

The first feed roller *G* is furnished with a pinion or wheel of 100 teeth; this impresses its motion upon another wheel bearing 80 teeth fixed to the second fluted roller; this latter is driven by a large wheel of 150 teeth, the motion of which is transmitted to a pinion having 52 teeth. What is the draught effected by the drawing roller?

Driving $100 \times 150 = 15000$

Driven $80 \times 52 = 4160$.

Then: $\frac{15000}{4160} = 3.605 =$ the first draught.

Calculation of the Second Draught.

The second drawing set is composed of about the same elements as the first. The pinion or wheel adapted to the feed roller has 80 teeth. This wheel imparts its motion to that fixed to the second drawing roller bearing 75 teeth; this latter receives its motion from a large wheel of 150 teeth, which communicates its motion to the pinion adapted to the drawing roller and carrying 67 teeth.

Driving $80 \times 150 = 12000$.
Driven $75 \times 67 = 5025$.

Then: $\frac{12000}{5025} = 2.388$ = the second draught.

Or, in other words, we have for the entire frame:—

1st draught	3.605
2d draught	2.388
Total draught . .	5.993

If for another batch of wool, it is desired to draw more or less, the regulating pinions are changed, according to the following rule:—

The actual draught is multiplied by the pinion producing it, and this product is divided by the required draught; the quotient gives the number of teeth of the new change pinion.

Example 1.—The first draught, produced by means of a pinion of 52 teeth, is 3.6; and we wish to reduce it to 3. What must be the number of teeth of the change pinion?

$\frac{3.6 \times 52}{3} = 62.4$ teeth.

EXAMPLE 2.—The second draught is 2.38, and the pinion producing it bears 67 teeth; what pinion do we need to use to obtain a draught of 2?

$\frac{2.38 \times 67}{2} = 79.7$ teeth for the change pinion. The total draught is then 5.

NUMBERING OF THE PREPARATIONS.

The numbering of the slivers of wool, in process of preparation in the drawing frames, is of great importance, by aiding us in verifying the progress of the work. Without such numbering, it is certain that we should begin upon a quantity of wool without precisely knowing what quality of yarn we should be able to produce from it. It is therefore evident that, in order to manufacture any given number of yarn, it is necessary to number also the slivers of wool in course of preparation, and follow exactly the degree of this numbering.

Proceeding by guess-work is a continual source of error; while, on the other hand, nothing is more rational or more simple than the use of calculation to determine such operations as these.

In order to establish a positive starting point for numbering the preparations, I base it upon the number of the yarn. Thus, I remark that No. 1 in yarn represents 500 metres weighing 500 grammes, or 1000 metres weighing 1000 grammes (1 kilogramme), which amounts to the same thing; and I then establish the following rule:—

That No. 1 of the preparations shall be represented by a constant number of 50 metres weighing 500 grammes, or 100 metres weighing 1000 grammes. The

number of the preparation, then, though the same as regards weight, will be one-tenth the length of the corresponding number of yarn, and consequently the sliver will be ten times as large, and may be drawn out without difficulty from 1 to 15.

Thus, the unit of the preparations is recognized as such, that No. 1 weighs 500 grammes for 50 metres of sliver. This system appears to me to be logical.

We will also agree that the letter P shall accompany all the numbers of the preparations, whatever they may be; and thus, to indicate the number 40, we should write 40^{p}. The numbers of the yarns shall be represented by figures alone, without the addition of the letter P. As may be seen, the number of the preparation, by the draught, is equal to that of the yarn.

EXAMPLE.—No. $40^{p.} \times 10 =$ No. 40.0 of yarn.

We have said that the sliver of the preparation is but one-tenth the length of the yarn, and this indicates a constant draught of 10; but, as wools are drawn more or less, the number should vary according to the qualities required. We will add that we should always exercise care, in order to obtain the exact number, to separate by a comma or dot the last cipher of this product; thus, instead of 400 we write 40.0.

EXAMPLE.—Having a preparation of No. $35^{p.}$, we wish to make No. 40, what shall be the draught?

The rule to be pursued is to *divide the number of the yarn by the number of the preparation; the quotient will give the draught.*

$$\frac{40}{35^{p.}} = 11.4 = \text{the draught.*}$$

* The quotient of $\frac{40}{35} = 1.14$; but, as in our system of numbering the

The rovings of the last drawing frames often break in spinning, especially if we wish to spin very high numbers, for the roving becomes so weak as not to be able to resist the unrolling. To obviate this great defect, the slivers or rovings are prepared a little coarser, and are then more susceptible of being drawn out.

This is not done among the lower numbers; but from No. 50 upwards, the slivers of the preparation may be made a little stronger. Thus, in the following example: to make No. 80 yarn with a sliver or roving, the nature of which does not give sufficient strength for resistance in unrolling, at what number of preparation is it necessary it should be made?

We have admitted that the draught of wool varies from 1 to 15; we will choose 13 as the draught, though it should be understood that we might equally as well have chosen 15. The formula is as follows:—

Divide the number of yarn to be produced by the desired draught, and the quotient will give the number of the preparation; care being had to leave only one cipher separated at the right of the figures.

$\frac{80}{13} = 61.^{p.}5 =$ No. of the sliver.

The calculations may be infinitely varied, in order to get at an exact result.

It sometimes happens that we do not have 50 metres of the preparation to sample, and yet it is often useful to

preparations, the sliver is one-tenth the size of the corresponding number of yarn, for the same weight, the quotient or draught becomes 11.4. For instance, if No. $35^{p.}$ were drawn 10 times, the number of yarn produced would be No. 35, and for making No. 40 yarn, No. $35^{p.}$ must be drawn more than ten times, or, according to the rule, 11.4 times.

ascertain its number. In this case, *the number of metres is divided by the weight, and the quotient gives the required number.*

Example.—A sliver 17 metres 50 centimetres long weighs 15 grammes, what is its number?

$$\frac{17.50}{15}=1.^{p.}16.$$

All numbers of yarn or of preparations are obtained by *dividing the unit by the weight of the sample.*

What is the number of a preparation weighing 25 grammes?

$$\frac{500}{25}=\text{No. } 20^{p.}$$

In order to ascertain the weight of a sample of any preparation, knowing its number, *divide the unit by the number, and the quotient will indicate the weight.*

Example.—Wishing to know the weight of a sliver or preparation numbered as 19, we have:—

$$\frac{500}{19}=26.3 \text{ grammes.}$$

In order to obtain the weight of numbers under the unit, we employ the same formulæ. When we come to doubling, we shall indicate the numerical value of the doubled slivers, so as to give a guide for all operations.

In order the better to exemplify this method, we have given the value in weight of the numbers of slivers, rovings, &c., in course of preparation. The operator can consult this table, when working, and construct one conformable to the kind of machines he has at his disposal.

For some kinds of goods much draught is necessary;

while for others is required very little; but in a word, this table will serve as a basis for all operations, whatever the manufacture may be.

Table showing the Numbers of Preparations with their corresponding Weights.

(The unit of weight is the gramme.)

Numbers for 50 metres.	Correspond-ing weight.	Numbers for 50 metres.	Correspond-ing weight.	Numbers for 50 metres.	Correspond-ing weight.	Numbers for 50 metres.	Correspond-ing weight.
1	500.00	26	19.23	51	9.80	76	6.57
2	250.00	27	18.52	52	9.62	77	6.49
3	166.67	28	17.86	53	9.43	78	6.41
4	125.00	29	17.24	54	9.26	79	6.33
5	100.00	30	16.67	55	9.09	80	6.25
6	83.33	31	16.13	56	8.93	81	6.17
7	71.43	32	15.62	57	8.77	82	6.10
8	62.50	33	15.15	58	8.63	83	6.02
9	55.55	34	14.71	59	8.47	84	5.95
10	50.00	35	14.29	60	8.33	85	5.88
11	45.45	36	13.89	61	8.19	86	5.81
12	41.66	37	13.50	62	8.06	87	5.74
13	38.46	38	13.16	63	7.94	88	5.68
14	35.71	39	12.82	64	7.81	89	5.62
15	33.33	40	12.50	65	7.69	90	5.55
16	31.25	41	12.19	66	7.57	91	5.49
17	29.41	42	11.90	67	7.46	92	5.48
18	27.78	43	11.63	68	7.39	93	5.38
19	26.30	44	11.35	69	7.24	94	5.32
20	25.00	45	11.11	70	7.14	95	5.26
21	23.81	46	10.87	71	7.04	96	5.20
22	22.73	47	10.64	72	6.94	97	5.15
23	21.74	48	10.41	73	6.85	98	5.10
24	20.80	49	10.20	74	6.75	99	5.05
25	20.00	50	10.00	75	6.66	100	5.00

It is to be well understood that 50 metres of sliver in preparation, when hooked to the arm of a steelyard, will

give the number of the yarn when multiplied by the draught which is 10.

This is the basis of the table, and consequently, if we wish to draw less than 10, we must make the number conform to the required draught, which is arrived at by the formula given above. One of the formulæ also indicates the number of a preparation necessary to produce any given number of yarn.

As has been seen, the number of the preparation multiplied by the draught equals the number of the yarn. Thus, with the letter D, indicating the draught, we have No. $40^{p.} \times 12^{d.}$ = No. 48.0 of yarn.

As has been already said, the slivers coming from the back-washing machine are always bulky, but rarely surpass the weight of 500 grammes to 50 metres, that is to say that they mark No $1^{p.}$. As they are to indicate the number of the doubling, we are obliged to go below the unit. For instance, if we carry 4 slivers to be doubled, each indicating No. $1^{p.}$, we shall be obliged to represent the 4 slivers as forming a number.

Thus, 4 slivers No. $1^{p.}$ give $\frac{1^{p.}}{4}$ = No. $0.^{p}25$.

The number of preparation, divided by the number of slivers going to form the doubling, gives the number of the doubling.

Result of the First Passage.

In order exactly to follow the operation we have undertaken, in speaking of the first drawing frame, it remains for us to show the number which the sliver will bear on leaving that machine.

The weighing of the spools was intended to regulate the first passage (first drawing process), and the subsequent operations. We must remember that the sliver, on being back washed or combed without oiling, weighs 500 grammes, or, in other words, represents No. $1^{p\cdot}$.

Since the mounting of the head of a first drawing frame consists of 4 spools, the number of the doubling will be $\frac{\text{No. } 1^{p\cdot}}{4 \text{ slivers}} = \text{No. } 0.^{p\cdot}25.$

When, however, we wish to know the number which will leave the frame, we have to take the draught into consideration; and since we know the draught of this machine to have been fixed at 6, we may carry the draught to 8 without inconvenience, for the machine draws at two points. Then, *multiply the number of the preparation by the draught, and the product will be the number of the drawn sliver.*

Thus we shall have $0.^{p\cdot}25 + 8^{d\cdot} = \text{No. } 2^{p\cdot}$.

It is of course to be understood that, in order to find the draught, we must consult the foregoing formulæ, which give us the steps to be taken in all subsequent operations.

The spools which result from the first drawing process, again require some control to verify their regularity. Therefore, care is to be had, 1st, to cause the spools to be weighed before being subjected to the action of the first drawing frame; 2d, to weigh again the spools when they leave the frame, in order to regulate their number; 3d, to reduce the volume of the slivers at each passage, in order to bring them to such a degree that they may be spun at the required number.

SECOND PASSAGE.

Second Drawing Frame—8 Combs, 4 Spools.

This frame is intended to reduce the slivers from their original volume; it has, like the first drawing frame, the advantage of uniting several slivers into one. This machine is supplied with 8 combs and 4 heads, so as to form 4 spools; like the first drawing frame, it has behind it a creel bearing 16 spools, so that each comb receives 2 slivers, and each head the product of two combs; the whole resulting in 4 slivers.

The draught of this machine is rarely carried beyond 7, but is to be regulated according to the nature of the material and the number to be spun, for all wools are not susceptible of the same amount of draught. Some of them will stand being drawn out from 6 to 7; others, on the contrary, cannot exceed 5, which is in all probability due to the weakness in the staple of such wools.

The spools, on leaving the first drawing frame, are subjected to a second weighing, in order to ascertain their regularity. In the case of their being irregular, we should arrange a mounting, *i. e.*, combine their weights in the manner we have followed for the first drawing frame.

The spools, on leaving the first drawing frame, weigh from 4 to 5 kilogrammes. Let us remember that the second drawing frame, having 4 spools in front and 16 mounted on the creel, has 4 of them per head. If it is found in weighing that the spools are of various weights, the mountings should be arranged as follows:—

First Head.

1	spool of	4	kilo.	900	grammes	17 kilogrammes.
1	"	4	"	100	"	
1	"	4	"	000	"	
1	"	4	"	000	"	

Second Head.

1	spool of	4.800	kilo.	17 kilogrammes.
1	"	4.100	"	
1	"	4.100	"	
1	"	4.000	"	

Third Head.

1	spool of	4.700	kilo.	17 kilogrammes.
1	"	4.100	"	
1	"	4.200	"	
1	"	4.000	"	

Fourth Head.

1	spool of	4.500	kilo.	17 kilogrammes.
1	"	4.100	"	
1	"	4.300	"	
1	"	4.100	"	

A similar irregularity never presents itself, especially when the first spools have also been weighed.

We see that by operating in this manner, each mounting has the same weight, notwithstanding the differences existing among the spools themselves.

I shall dwell upon this passage (2d drawing process) long enough to establish the calculations necessary for the distribution of the draught and the number.

In order, for instance, to reach No $40^{p.}$ on the finishing drawing frames, we have still 38 numbers to reduce, for we left the first frame with No. $2^{p.}$ We have still 7 passages (drawing processes) by which to cause this difference to disappear, which makes an average of 6 numbers to one frame.

The first passages reduce greatly in volume, but very little in number, for the slivers are very compact.

Knowing that the No. $2^{p.}$ is to be doubled by 4 slivers, with a draught of 7, we find:—

$$\frac{2^{p.}}{4} 0.^{p.}5 \text{ and } 0.^{p.}5 \times 7^{d.} = \text{No. } 3.^{p.}5.$$

It results from experiment that the draught of each machine varies from 1 to 8, and is subordinated to the degree of doubling; for the more slivers the doubling has, the greater the draught. It is proper to say that the doubling by 4 is generally considered good, and it is difficult also to work with a higher doubling, especially when we come to the last drawing frames.

We have said that the spools, on leaving the second passage, indicate on the steelyard No. $3.^{p.}5$.

THIRD PASSAGE.

Third Drawing Frame—12 Combs, 6 Spools.

This machine possesses twelve combs, the fineness of which may be found from the table of combs. The creel contains a mounting of 24 spools and 6 outlets, which makes 4 spools for each head to make one.

Just as in the former machine, each comb receives 2 slivers; 2 combs concur to form one sliver, which passes under a cast-iron roller, or any other, according to the

construction of the machine, and then is rolled into a spool as usual. A traverse motion regulates the laying on of the sliver.

The spools leaving this machine are very regular, and consequently present less chance of error in numbering, so that it becomes useless to re-weigh them. Notwithstanding this, the foreman should sample the product every now and then.

We now pass to an analysis of the numbering of this passage.

The number $3.^{p.}5$ obtained on the second drawing frame should be doubled by 4 slivers on this third frame, which will give us a doubling number of $\frac{3.^{p.}5}{4} = \text{No. } 0.^{p.}875.$

If we should desire to know what number we shall have when the wool leaves this machine, we will suppose a draught of 6, which will give us—

$$6^{d.} \times 0.87 = \text{No. } 5.^{p.}22.$$

Steam as Applied in the Drawing Process.

Steam, for some time past, has been employed in several spinning mills to facilitate the preparation of the wool; it is principally for fine numbers that this system is adopted. It has been tried in order to fix the filaments of coarse wools under preparation, but does not seem to have given successful results. It will be understood that as this agent reaches a temperature of over 100 degrees centigrade, it causes a softening of the filamentous material, and may, therefore, bring about serious chemical changes in its substance, and spoil immediately a part of the material in course of preparation, especially

if the wool has a tendency to felt. This is the reason why the process succeeds better with fine wools.

This method, when employed with prudence, does well enough for fine materials, although as I have said it is a dangerous agent.

The steam is applied through a system of distributing pipes, and is brought in contact with the wool as it passes through the funnel, by means of small jets. The higher the temperature of the steam, the greater the tendency of the wool to become yellow.

FOURTH PASSAGE.

Fourth Drawing Frame—12 Combs, 12 Spools.

This machine is composed of 12 combs and 12 spools. The creel carries 48 spools or less, according to the kind of doubling.

This is a machine which requires special care on the part of the operator. Fig. 33, Pl. XI. represents a drawing frame built by M. Brunneaux, Sr., of Rethel. The same builder is the inventor of a similar frame with double sliver which is working with success in several spinning mills. This firm has, for some time past, been making great changes in the construction of all preparatory machines with a view to lessening the cost of building them.

The plate represents a view of the machine, from above, which I believe is the best means of demonstrating its mechanism and working.

Motion is transmitted by one of the pulleys, which may be seen near the bevel gear. On the shaft of these pulleys is a large bevel wheel, gearing with another, the

shaft of which is supplied with two excentrics H. This transmission is perfectly supported, and rendered so firm as to prevent oscillations, which always occasion injurious effects.

Not being able to give a plan of the machine in its entire length, I have broken the diagram so as to leave at least two heads and the mechanism of the end of the frame. In this manner we shall be able to follow the course of the operation.

G is the creel, on which are seen the different tiers for placing the spools.

A. First row of feed rollers.

B. Row of guide rollers.

C. Combs.

D. Row of drawing rollers, with their top rollers.

E. Leathers.

F. Spool drums.

On the side of this line representing the drawing process actually going on, we observe all the fluted rollers without top rollers, the tables naked, and then the spool drum.

This is what takes place during the working of the machine:—

The spools G unwind, being pulled upon by the feed roller A, which delivers the slivers to the next one B, at the same time that it slightly draws them so as to bring their fibres into line. The sliver on leaving this latter roller, passes upon the comb C, is drawn out by the roller D, and is then carried under the leathers E, which are driven by the eccentrics H. Through the traverse motion given by the latter, the sliver is rolled, and assumes a certain amount of consistency, which al-

lows it to stand the process of unrolling. From thence the sliver enters the funnel, to be wound off on the wooden spool.

The doubling upon this machine generally consists of three slivers, although it may be made with four.

We have said that the spools, on leaving the third drawing frame, had reached No. $5.^{p.}22$, so that the number of slivers being 3, we shall have $\frac{5.^{p.}22}{3} = \text{No. } 1.^{p.}74$ for the doubling; and, in order to reduce this number to No. $9^{p.}$, we shall find, according to the previously established rules, that the draught will be $\frac{9}{1.74} = 5.^{d.}17$.

Cuttings.

Before going on with the subsequent drawing processes, we think we should here mention the grave defects caused by breakings and cuttings, which are often to be seen in the slivers.

When these defects arise, the first care of the foreman should be to examine the machines, and stop those which produce these irregularities.

Cuttings are generally due to:—

1st. Badly proportioned intervals between the comb and the second roller.

2d. An obstructed funnel which evidently produces a narrowing sliver.

3d. A comb badly fastened to its shaft.

4th. An irregular motion of the comb shaft, from not being properly in gear.

5th. A comb, the pins of which are turned back.

6th. An obstructed top roller, producing a jolting motion destructive to regularity.

7th. Any roller obstructed or not lubricated, and moving by jerks.

8th. Any roller which has lost its cylindrical shape, either by crushing or from the cloth having become unglued.

9th. A hard body attached to one top roller and occasioning, each time the latter passes over the fluted roller, an aperture allowing the sliver to pursue its own course.

10th. The parchments, especially when they are not supple, for then they do not bring about perfect contact with the fluted rollers; and cuttings are common when we undertake to treat fine short wool with heavy parchments.

11th. Combs not having a sufficient number of pins, or whose pins are unsuited to the wool under treatment.

Yarn obtained from prepared wool in which there are cuttings is unfit for sale; and it is therefore an object of vital importance to the wool spinner to prevent the occurrence of this defect.

It may be said that there is still a remedy, even when a preparation is full of cuttings. To this we shall answer yes; but this result ought still never to occur, for the men charged with the working of the drawing machines, ought by their skill and experience, to prevent any defects in their operation.

The best means of utilizing a prepared wool, when cut, if there is only a small proportion of it damaged, is to carry it back to the first drawing frame. This irregular sliver, being of no great bulk, disappears in the new sliver as it is drawn out. If there are several of such

cut slivers, one is mounted on each head. When. however, a considerable portion of the lot is in this condition, it should be doubled with a perfect sliver, by giving it one or more additional passages.

Notwithstanding all these remedies, the sliver is never as regular as it should be, and is also more costly of manufacture.

Barbs (Roller Waste.)

Barbs or tufts cause irregularities in the sliver, and increase the cost of the manufactured material.

Barbs are not so frequent since wools are properly scoured.

The causes producing them are:—

1st. Imperfect scouring.

2d. Fleece-bound wool.

3d. Unclean rollers.

4th. Worn-out top rollers.

5th. Fluted rollers, the flutes of which have been injured by some hard instrument.

6th. Worn-out parchments.

7th. Rents or scratches on the leather rollers.

8th. Hard bodies imbedded in the rollers.

9th. Combs, the pins of which are turned back.

10th. Combs, the working of which is not graduated according to the wool.

A well-conducted machine occasions scarcely any barbs or tufts, except such small ones as become detached from the sliver, and are caught by the top clearers.

In order that the wool may be well caught under

the drawing roller, in passing through the comb, a fixed iron rod is laid horizontally a little below the summit of the comb; and by this means the wool is obliged to enter the latter.

Thanks to a new invention which has been recently been put in use, barbs have almost entirely disappeared, especially those occasioned by the top rollers, which are in the majority; those resulting from other parts of the machine being quite few.

This invention is very simple, and is due to Mr. Ferdinand Buignet. It consists of two well-polished turned iron cylinders, acting on the wool as it leaves the drawing roller. These cylinders almost touch the rollers, and are driven by wheel gear at whatever rate we may desire; but the velocity is so regulated that the wool may not be drawn after leaving the drawing rollers; in other words, these iron cylinders perform the office of guides. The parchments are cleaned by passing against them.

No wool spinner should hesitate to use this appliance,* which is not costly.

Piecing or Splicing.

Piecing may at first sight appear to be a matter of little importance, but this is not so, for a single bad joining produces a disturbance in the work.

When a sliver breaks, the workman should split one of its ends, and make the splice by inserting the other end into the V, and then make the joining strong by

* Write, prepaid, to Mr. C. Leroux, mechanical engineer, at Hangest sur Somme (Somme), France, for any details.

rolling it between his fingers, and afterwards flattening it out. This may be done in a second.

Piecings which have been too much twisted do not disappear entirely, especially if they are made during the last passage (drawing process); we must therefore avoid rolling the slivers upon too hard a substance, especially with the aid of spittle.

Waste.

Waste is divided into two classes.

The first class embraces:—

1st. Fine waste.

2d. Waste for drawing, &c.

The second class embraces:—

1st. Waste gathered from the bearings.

2d. Waste gathered from the top clearers.

3d. Flyings and sweepings.

No waste from the drawing frames should remain upon the floor.

Every Saturday night, after clearing, the women deposit their waste with the foreman.

The waste of the first class is susceptible of being worked over into inferior qualities, and that of the second class may be sold for the manufacture of carded yarn.

FIFTH PASSAGE.

Fifth Drawing Frame—24 Combs, 24 Spools.

This frame is constructed after the same plan as the preceding one; but as its object is to reduce the num-

ber of the preparation, the number of combs is 24 for 24 spools. We double by 3, which makes 72 spools on the creel.

One thing to be attended to, in regard to the drawing frames, is to clean the combs when they are clogged with dirt; for the unfortunate habit prevails of allowing the combs to work a long time in such a condition.

Combs charged with impurities destroy the regularity of the drawing, because these foreign bodies occupy the space through which the wool filaments should pass during the drawing process, and to this end, the bases of the pins should be frequently cleaned.

Let us now return to the calculation of this passage, and see the number we shall obtain.

Knowing that the number we start on is $9^{p.}$, and that the doubling is to consist of 3 slivers, we shall have $\frac{9^{p.}}{3} = \text{No. } 3^{p.}$.

If we adopt for this machine a draught of 5, we shall have $5^{d.} \times 3^{p.} = \text{No. } 15^{p.}$

SIXTH PASSAGE.

Sixth Drawing Frame—16 Combs, 32 Spools.

This frame with double sliver for one comb begins to be appreciated by manufacturers, and very good results are obtained from it. Several spinning mills of the Nord are employing this machine, which is not longer than others with simple slivers. It is advantageous from the fact that it requires but one woman to look after it, instead of two, and that a very long frame is always more

difficult to be attended to; for such a one is more easily injured by jarring than the frame with double sliver, the length of which is only one half as great.

The drawing frame which we employ in the sixth passage, is supplied with 16 combs and 32 spools in front; the creel consequently carries 96 spools in doubling by 3.

The slivers united by three, pass through the comb, each comb receiving two slivers which are drawn out, and pass under the leather rubbers; after leaving these rubbers, the slivers are always kept divided, notwithstanding the rubbing. These two slivers are then wound off to a spool.

The spools taken from the fifth passage give us No. $15^{p.}$, and in doubling by 3 we shall have $\frac{15}{3}=$No. $5^{p.}$ If we dispose the draught to be 5, we obtain $5^{p.} \times 5^{d.}=$No. $25^{p.}$

SEVENTH PASSAGE.

Seventh Drawing Frame—20 Combs, 40 Spools.

This frame is similar to that of the sixth passage; the front spools are 40 in number. By following the same system of numeration, we shall be able to produce a sliver for spinning yarn No. 40.

Here again, two slivers are combed by one comb.

The preparation received from our sixth passage gave No. $25^{p.}$, we double by 4, which will give us $\frac{25^{p.}}{4}=6.^{p.}25$ for the doubling.

If we allow a draught of 5, we obtain $5 \times 6.^{p.}25=$No. $31.^{p.}25$.

From this we may conclude that the more the slivers increase in number, the less the draught becomes; for, if the draught should be too great, we should immediately exceed the desired end.

It is especially at this passage or next to the last, that it is important to verify or prove the regularity of the product, for at the last it is too late.

EIGHTH PASSAGE.

Eighth Drawing Frame—48 Combs, 48 Spools.

The double frame (two slivers to one comb) here employed, has 48 combs and 48 spools. It is of course longer than the preceding one. With this machine we shall terminate the drawing processes, and it is therefore, in the present case, the finishing frame which will produce the roving for spinning. There are some arrangements which require several drawing frames for the last passage and that preceding it; this depends upon the number of spindles to be supplied, and the kind of yarn to be spun. Thus, for supplying a fine quality of yarn, fewer sets of machines are required than for preparing the coarser kinds, which consume an enormous quantity of wool.

It is for this reason that I have undertaken the experiment upon a system composed of 8 passages, especially destined to produce numbers up to 60.

Each series of numbers, from 10 up to 50, requires a particular set of machinery; the same is true from 50 to 100, and from 100 to 200.

We have employed eight passages in preparing the

numbers with which we have here been concerned. We might, evidently, have produced these numbers with fewer passages, but I doubt whether they would have been as regular; a greater number of passages, however, would be useless with wools of this character or these numbers. Fine numbers certainly require more passages, for they are exceedingly sensitive after passing No. 50; we may go as high as 11 and even 12 passages without doing harm, though I repeat it, it is useless for ordinary numbers.

The spools we have obtained at the seventh drawing process are marked as No. 31.$^{p\cdot}$25; we still double with 4 slivers, and we have:—

$$\frac{31^{p\cdot}25}{4} = \text{No. } 7^{p\cdot}81.$$

Wishing to produce the number of the last preparation, we must know either the draught or the number.

Suppose that we do not know the draught, and that we wish to produce yarn No. 40, we must have, as it has been explained, a roving bearing the No. $40^{p\cdot}$

Thus we shall have $\frac{40^{p\cdot}}{7.^{p\cdot}80} = 5.13 =$ the draught necessary to produce $40^{p\cdot}$.

The number leaving the finishing drawing frame then indicates the required number, plus the draught. For instance:—

$\frac{40 \text{ yarn}}{40^{p\cdot}} = 10$, which is the draught necessary for making yarn No. 40.

If the sliver were too large and marked some other number, this would not prevent us from making the re-

quired yarn, if the draught did not exceed a certain limit.

Suppose that a sliver or roving of No. $28^{p.}$ is destined to make No. 40, we shall find a draught which will still be possible: $\frac{40}{28^{p.}} = 14.3$ draught.

But, I repeat it, wools too much drawn never result as well as those drawn from 1 to 10.

In order to avoid loss in sampling, samples of ten metres or more are generally employed; but this is of no consequence, for we keep account of the difference. I have given, in my remarks on numbering, the method of obtaining it.

The unit for drawing preparations is from 1 to 10, but it is preferable to draw less. It is principally in the first passages that the greatest draught takes place, in order to reduce the excessive bulk of the slivers leaving the back washer.

The rule indicates for the first passages, a draught of from 5 to 8.

For the intermediate passages, a draught of from 5 to 6.

For the finishing passages, a draught of from 3 to 6.

Doubling.

This process has for its object the regularity of the slivers, at the same time that they are drawn out better.

It is made by 2, by 3, and by 4.

For the sake of greater regularity, doubling is effected by 4, especially during the latter passages; and hence we must conclude that the regularity of the product is

greater by 4 than by 3. Thus, if a sliver breaks in the doubling by 3, there only remains two-thirds of it to be worked upon; whereas if it breaks in a doubling of 4, there will remain three-fourths of the material to continue the operation.

I do not wish, however, to draw the conclusion that therefore all doublings should be made by 4, for we have ourselves employed several of 3 in the experiments we have been making on the drawing process.

Doubling is subordinated to the numbers of the first slivers, and also in comparison to those of the finishing drawing frame.

Breaks during doubling will occasion single strands; this is a great defect, and will occur notwithstanding the strictest supervision. A workwoman who allows a piece of single, over one metre in length, to pass, becomes subject to a fine.

Bad spooling on the preceding frame may occasion breakages upon unwinding; the foreman should ascertain the exact causes of this accident, so as to prevent any deterioration of the material.

Table showing the Numbers of Slivers employed upon each Drawing Frame, the Numbers of the drawn out Slivers, and the corresponding Draughts.

Number of passages upon the drawing frames.	Number of slivers for doubling.	Number of the doubling.	Draught.	Number of the drawn out sliver.	Number of the yarn which can be spun with those slivers.
1st Passage or drawing process,	4	$0^{p}.25$	8	2^{p}	
2d " " "	4	0.50	7	3.50	From
3d " " "	4	0.87 5	5.50	4.81	10
4th " " "	3	1.60	5	8	to
5th " " "	3	2.66	4	10.64	15
6th " " "	4	2.66	4	10.64	
7th " " "	4	2.66	3.75	10	
1st Passage or drawing process,	4	0.25	8	2	
2d " " "	4	0.50	6.50	3.25	From
3d " " "	4	0.81 2	5.50	4.46	15
4th " " "	3	1.48	5.25	7.77	to
5th " " "	3	2.59	4 50	11.65	22.5
6th " " "	4	2.91	4.25	12.36	
7th " " "	4	3.09	4.84	15	
1st Passage or drawing process,	4	0.25	8	2	
2d " " "	4	0.50	6.50	3.25	
3d " " "	4	0.81 2	6	4.87	From
4th " " "	3	1.62 4	5.50	8.93	20
5th " " "	3	2.97	5.50	13.36	to
6th " " "	4	3.34	4.25	14.19	33
7th " " "	4	3.72	4.75	17.67	
8th " " "	4	4.41	5	22.05	
1st Passage or drawing process,	4	0.25	8	2	
2d " " "	4	0.50	7	3.50	
3d " " "	4	0.87 5	6	5.25	From
4th " " "	3	1.75	5.50	9.62	30
5th " " "	3	3.20	5	16	to
6th " " "	3	5.33	4.50	23 98	50
7th " " "	4	7.74	4	30.96	
8th " " "	4	7.74	4.25	33	

Number of passages upon the drawing frames.	Number of slivers for doubling.	Number of the doubling.	Draught.	Number of the drawn out sliver.	Number of the yarn which can be spun with those slivers.
1st Passage or drawing process,	4	$0^{p}.25$	8	2^{p}	
2d " " "	4	0.50	7	3.50	
3d " " "	4	0.87 5	6	5.25	From
4th " " "	3	1.75	5.75	10	45
5th " " "	3	3.33	5.50	18.31	to
6th " " "	3	6.10	5	30.50	67
7th " " "	4	7.62	4.75	36.19	
8th " " "	4	9.04	4.50	40.68	
9th " " "	4	10.17	4.42	45	
1st Passage or drawing process,	4	0.25	8	2	
2d " " "	4	0.50	7	3.50	
3d " " "	4	0.87 5	6.50	5.68	From
4th " " "	3	1.89	6	11.34	50
5th " " "	3	3.78	5.50	20.79	to
6th " " "	3	6.93	5.25	36.38	85
7th " " "	4	9.09	4.50	40.82	
8th " " "	4	10.20	4.50	45.90	
9th " " "	4	11.47	5	57.35	
1st Passage or drawing process,	4	0.25	8	2	
2d " " "	4	0.50	7	3.50	
3d " " "	4	0.87 5	7	6.12	
4th " " "	3	2.04	6.50	13.26	From
5th " " "	3	4.42	6	26.52	70
6th " " "	3	8.84	5	44.20	to
7th " " "	4	11.05	5	55.25	112
8th " " "	4	13.80	4.50	62.10	
9th " " "	4	15.52	4.50	69.84	
10th " " "	4	17.46	4.29	75	

The draught indicated in the table may be varied, for all wools, as we have said, do not undergo the same amount of draught. If we wish to make fine numbers with few machines, it is impossible to draw beyond the

prescribed rule; but, in order to obtain the result, we double less, so that in consequence there will be less draught to be done for the same number.

Thus, if we desire to make No. 30 with the first set of frames, we should double by 3, and in this manner, the desired number will be possible. If we wished to make this number upon 7 machines with a doubling of 4, this could not be done, unless we brought a higher number of sliver to the first drawing frame.

It will perhaps be thought strange that I should use the same number on the first frame, and at each series of passages; I have taken this number for a type, as being very large and difficult to reduce.

In the preceding table will be found the number of slivers composing the doubling. I have numbered this doubling, that is to say, I have obtained the number either by multiplying the weight of the slivers, or by dividing the number of the preparation by the number of slivers forming the doubling.

All the spools leaving the finishing frame are carried into a store-room where they are allowed to rest for a time, and are afterwards spun.

When a set of spools of roving is mounted behind the spinning frame, and when the prepared wool has not been laid aside in the storeroom for a certain time, the spinning will be less successful than if the wool had rested and regained a certain amount of softness.

Wool leaving the last drawing frame, and then immediately spun, causes a loss in flyings, breakages, and variations in numbers, on account of an excess of dryness.

The slivers of prepared wool correspond in number to

the yarn, for the finer the slivers are, the finer the yarn will be, and conversely.

Table of the Slivers or Rovings of Preparation with the corresponding Numbers of Yarn.

Number of the slivers or rovings of preparation. Length, 50 metres.	Draught in spinning.	Number of the yarn.	Weight of the slivers or rovings for a length of 50 metres.
No. 10p	From 1 to 15	from 10 to 15	50.00 grammes.
15	1 to 15	15 to 22.5	35.71
20	1 to 15	20 to 30	25.00
25	1 to 15	25 to 37.5	20.00
30	1 to 15	30 to 45	16.67
35	1 to 15	35 to 52.5	14.29
40	1 to 15	40 to 60	12.05
45	1 to 15	45 to 67.5	11.11
50	1 to 15	50 to 75	10.00
55	1 to 15	55 to 82.5	9.09
60	1 to 15	60 to 90	8.62
65	1 to 15	65 to 97.5	7.79
70	1 to 15	70 to 105	7.14
75	1 to 15	75 to 112.5	6.66
80	1 to 15	80 to 120	6.25
85	1 to 15	85 to 127.5	5.88
90	1 to 15	90 to 135	5.55
95	1 to 15	95 to 142.5	5.26
100	1 to 15	100 to 150	5.00
105	1 to 15	105 to 157.5	4.76
110	1 to 15	110 to 165	4.54
115	1 to 15	115 to 172.5	4.34
120	1 to 15	120 to 180	4.16

This table has been constructed in order to guide the operator in respect to the finishing drawing frame, so that the numbers obtained from that machine may correspond with the numbers of the yarn to be produced by the prepared wool.

Thus, for instance, in order to make No. 75, we shall

find opposite No. 75 in the first column, No. 75^p. plus a draught of 1 to 15.

If the draught is 10, the rule gives $75^{p.} \times 10 =$ No. 75.0.

Or, if we wish to know what preparation is necessary to make 60, with a draught of 13, we shall have:—

$$\frac{\text{No. } 60}{13} = \text{No. } 46^{p.}15.$$

It is useless to multiply examples, as it is only necessary to recollect what has been said concerning the calculation of preparations.

The working of the machines should be so arranged that they shall supply each other without delay. It is absurd to gain time on a machine which has to supply another, for there will come a time when it will be obliged to stop, and by so doing, stop the preceding one, throw the whole work into confusion, and thus always occasion loss.

CHAPTER XVIII.

FRENCH SPINNING ON THE MULE.

Spinning Mule.

We generally obtain yarn by spinning either on the English or French throstle frame, on a jack, or on the mules. Since the time of Crampton, these latter have been much improved in the matter of machinery, which formerly presented many difficulties in dismounting and changing. They are now employed in France with suc-

cess, and produce all the varieties of yarn required by French weaving.

The machine, which is to serve us as a type, is a mule constructed by Mr. Brunneaux, senior.

In order conveniently to spin upon the mule, it should be placed upon a level floor, so as to allow the carriage to work freely and without twisting.

The construction of these machines is very variable, each builder making them after his own model, and yet the resulting products differ very little from each other. At all events, their construction should be such that they may absorb the least possible power, and be strong enough for wear.

The mule has a greater or less number of spindles, varying from 160 to 300, according to its requirements. These frames being very long, and the carriage varying in the winding process, it becomes necessary to place the winding arrangement in the centre of the carriage. For this object a crank is used, which for frames of 200 spindles is fixed horizontally at the extremity of the machine, on the right hand. The same method is used in case of frames of 160 spindles.

The frame which we present here (Fig. 34, Pl. XII.), is one of 200 spindles.

A. Cast iron frame.
B. Horizontal crank handle.
C. Bevel wheel.
D. Driving pulley.
E. Grooved pulley.
F. Intermediate grooved pulleys.
G. Guide grooved pulley.
H. Drum.

I. Spindles.
J. Pulley driving the car (mandoza).
K. Wheels of the car.
L. Handle of the faller rod.
M. Gear of the drawing process.
N. Creel.
O. Drawing rollers.
P. Weighted top rollers.
Q. Rollers with parchments.
R. Spool of roving.
S. Bobbin of yarn.

This frame, when properly constructed, should possess five rows of rollers moved in the same direction by the gearing *M*, mounted at the head of the machine. It receives its motion from a belt carried over a small pulley *D*, fixed upon the shaft of the crank handle *B*. Upon this shaft is placed a bevel wheel *C*, which transmits motion to the gear *M*, which in turn drives all the rollers. Each row is surmounted with top rollers. The first *O*, intended to draw out the roving, is fluted, and receives the rollers *Q* covered with parchment. These cylinders receive from *P* the pressure necessary to laminate the rovings. At the back of the machine there is a creel *N*, which carries as many spools *R* as there are spindles. On the other hand, the great grooved pulley *E* communicates its motion to the spindles *I* by means of the pulleys *F*; and the guide pulley *G*, passing around the drum *H*, the carriage is moved by a belt placed upon the pulley *J*, while its wheels *K* revolve along a small iron track.

The five rows of rollers of which we are speaking are fluted, and receive two weighted top rollers, back and

front, the latter serving for the draught, and then three intermediary top rollers.

Pressures Given by the Top Rollers.

The top rollers of the spinning mule are variable in weight, but the intermediary top rollers remain always the same.

The rear weighted top rollers have a larger diameter than the intermediate top rollers, and are covered with calf-skin carefully glued. These rollers, when kept constantly clean, are very durable, but must never be scraped with a knife or steel instrument, for the scratches thus produced occasion irregularities in the yarn. The intermediate top rollers (not weighted) are of iron covered in the same manner as the preceding. They do not wear, and last a long time.

The drawing rollers receive their pressure from the same saddle or lever as those in the rear; but this pressure is greater, as it has to smooth as well as to draw out the roving. These rollers are made of turned wood, and traversed by an iron axle upon which rests the saddle of the lever. Each axle receives two rollers, and between the two the pressure is exerted. They are covered with an envelope of glued felt, and four little cuts with the saw are made crosswise of the circumference, in which are fixed four small sheets of parchment which serve as a regular envelope.

The pressures are greater or less according to the material to be drawn out, and vary from 4 to 10 kilogrammes, working to the best advantage when the rollers are perfectly true on their circumference, and well oiled

under the saddles. The presence of an accumulation of waste around the axles or the fluted rollers, sometimes occasions some delay in the action of the drawing roller.

Spindles.

Spindles, as we have already said, are more or less numerous, their number varying according to the kind of machine; they rest upon a plate bolster (step rail) which has as many steps as there are spindles. These spindles are of steel, and furnished each one with a wharl to receive the motion imparted by the drum, by means of a spindle band. Each spindle rests above the wharl, in a metallic collar. This collar is so made that the spinner and his assistant, when cleaning the machine, can remove the spindle from the collar, so as to free it from tufts of wool waste.

In frames of 160 to 200 spindles, the spindles are generally driven by bands; but in the large machines, those driven by gear are preferable, as they vary less in velocity.

The inclination of the spindles is from 12 to 18 degrees.

In treating the following numbers, we generally employ frames for:—

No.	18	to	20	of	160	spindles.
"	20	"	100	"	200	"
"	100	"	200	"	300	"

Notwithstanding this great difference in the number of spindles, it would not be fair to suppose that in working coarse numbers we could make a half more with a

frame of 300 than with one of 200 spindles. Evidently not; indeed perhaps less could be obtained, as the process of winding would present insuperable difficulties to the spinner, so that he would soon be tired out, and produce soft bobbins; for coarse yarns of large diameter and composed of very hard materials, will not arrange themselves so well upon the bobbins as do the finer ones, and especially because the frame is heavier than that of 200 spindles.

Carriage.

The arrangement of the carriage is such that it can advance or recede in parallel directions upon four little iron tracks. The extremity of the track should be elevated one degree, in order to facilitate the winding up.

The car takes a certain time in its course to go over the space which separates it from the drawing roller. This time is proportional to the number of the yarn to be spun. Thus, the finer the yarn, the longer the time will be, and conversely for the coarse numbers. At each stretch, the car stops to begin again, and *vice versa.*

This motion is generally impressed by means of the fly wheel handle and that of the faller rod, or by two endless screws. The first means is generally used. The motion of the carriage is also changed by means of pinions.

Cuttings.

Too great a pressure may perceptibly deteriorate the roving, and produce an uneven yarn, but cuttings are

generally the fault of the parchments, or of disproportionate intervals.

As was said when speaking of the parchments of the preparatory machines, the wool and the parchments must be proportional in their numbers, and it is necessary to repeat it here, for this last act of the drawing process necessitates many precautions. An arrangement of parchments should, therefore, be made according to the numbers of the yarn to be spun, as follows:—

Nos. of yarn from	10 to 20,	No. of parchment		1.
"	" 20 to 40,	"	"	2.
"	" 40 to 80,	"	"	3.
"	" 80 to 140,	"	"	4.
"	" 140 to 200,	"	"	5.

In order to spin numbers of yarn from 20 to 40, thence we shall know that we must take the second lot of parchments; and should we undertake to make yarn No. 80 with the first lot, it is very evident that the yarn would be entirely uneven.

When parchments grow old, they become dirty in a manner to depreciate the product, in which case they should be renewed.

A disproportion in the intervals, gives rise to the long cuttings, which are observable in the yarn. For rules upon this subject, we shall refer to those laid down in speaking of the preparatory machines.

The entrance of the funnel, when obstructed, tears the roving, and the same effect may be produced by the displacement of a roller. The rollers should be frequently changed; and thus, 15 spare rollers are necessary daily for 200 spindles.

Barbs (Waste).

When wools have been badly scoured, they frequently form barbs.

We designate by this name that part, or the whole of a roving, which in working twists itself around a pivot or a top roller; sometimes a bit of fleece-bound wool will produce this effect, but this is rare.

The common causes producing them are:—

1st. Worn out parchments.

2d. Dirty rollers.

3d. Badly scoured wool.

4th. Scratched rollers.

5th. Hard substances driven into the rollers.

6th. The flutings charged with fatty matters.

These barbs are placed in a box and kept separate from the other waste. The waste is divided into four qualities:—

1st quality, long barbs.
2d " soft twistings.
3d " end twistings.
4th " greasy barbs.

The long barbs are found wrapped around the middle of the rollers.

The soft twistings proceed from the extremities of the end twistings (first clearing of the roving).

The end twistings are due to breakage of the yarn, for the workman desirous of piecing his yarn, breaks off the extremity of the latter.

Greasy barbs are produced by the slipping of barbs on to the axles of the rollers, which are smeared with oil.

Spindle Cords or Bands.

Spindle bands are generally cotton, and should always be uniformly stretched; for without this precaution, the twist would be irregular, and there would be a loss of velocity.

Cotton bands are subject to atmospheric influences, which is shown by the fact that in damp weather they become so tense that the normal motive power is insufficient to drive the frame, and the same is true of the spinner who winds up with great difficulty; a condition of things which cannot last long without producing irregularity in the working.

This defect is remedied by placing a small stick between the bands and the wharl of the spindles. This should be done in damp weather at night, and when in the morning the workman withdraws the stick, the bands are found not to be too tight.

Breaks and Lashing (Running in).

Before submitting any wool to the spinning process, we should consult its degree of fineness, its length, and its power of resistance.

As are the diameters of the filaments, so will be the resulting yarn. It is therefore impossible to make fine and strong yarns out of common wools, whatever process we may employ.

The following experiment will serve to establish this statement. I submitted 6 fine filaments to a tension of 60 grammes; these 6 were equivalent in their diameters to one coarse filament; but the coarse filament was

broken at once, whereas the 6 others remained whole, which is a sufficient proof that the aggregate of several distinct diameters presents a greater resisting surface.

The yarns break when the rovings to be drawn out on the spinning frame, are irregular, and the machine produces barbs, or when with an inferior wool we have undertaken to manufacture a number beyond its strength. In the latter case, the yarn describes, during the progress of the car, a curve which indicates an approaching breakage.

In a good condition of the yarn, it should vibrate slightly without a curve.

When the yarns vibrate much, there often arises lashing or running in, especially when the slivers contain very long filaments which are not readily incorporated with the yarn ; but still, the vibration causes the defect, and vibrations are brought about by any enlargement or narrowing in the yarn.

Winding up.

There are several methods of winding up. By some it is performed by means of an ascending spiral, and by others the yarns are crossed in the upper cone, called the bobbin head. The latter system is most commonly in use ; by it, the bobbins are less apt to be injured in shape.

In order to accomplish a successful winding up, the spinner holding in his right hand the crank handle of the machine, and in his left the handle of the faller rod, draws the carriage slightly toward him, so as to stretch the yarn, and then lowers the faller rod after having raised the crank handle. Having done this, and the yarn

having sunk to the base of the bobbin, the workman winds it in spirals up to the summit of the cylinder, and continues crossing till he reaches the head.

Winding necessitates great care, both in regard to the motion and the precision indispensable in securing regularity in the operation.

Winding has been all the better done if the bobbin unspools well. The bobbin should present a regular appearance, and be quite hard to the touch. The butt should be conical, the body cylindrical, and the summit conical and crossed. All the bobbins of one operation should be of uniform weight, except in the case of broken yarn.

Intervals.

As in the case of the preparatory machines, the rovings are submitted to intervals depending upon the length of the filamentous material. These intervals are variable to the same degree as in the drawing frames, and therefore follow the order which I have indicated in the article on intervals. It would be useless to enlarge upon the subject, as reference can be made to that article.

Draughts.

The yarn made upon the mule is from 5 to 20 times as long as the roving producing it, that is to say that, in order to make a yarn of any kind, the roving must be drawn out as many times its own length as the material will allow. There are some wools which will not stand a draught of over 6, and others, on the contrary, which will undergo a draught of 15 without any deterioration.

When we wish to know the draught necessary to make a given yarn, *we divide the number of the yarn to be done by the number of the preparation, and the quotient gives the draught.*

We will calculate what is the proper draught to be arranged for the spinning frame in making No. 40, knowing that the roving on leaving the last drawing frame marks on the steelyard No. 40 of preparation, for 10 metres.

EXAMPLE.—$\frac{40}{4}=10=$the corresponding draught.

ANOTHER EXAMPLE.—Having a roving marking 4.2 for 50 metres of length, and wishing to make No. 40, what will be the proper draught?

$\frac{40}{4.2}=9.52=$the corresponding draught.

It is quite useless to use 50 metres as a sample of preparation, for 25 will suffice. For instance, the latter roving, instead of marking 4.2 upon the steelyard, will go up to 8.4; but as the sample is only of 25 metres, we divide 8.4 by 2 and have the same result, and thus avoid wasting material in samples.

REGULATING THE NUMBER OF THE YARN.

In order to regulate the spinning so as to insure uniformity, and at the same time be able to change the numbers at will, every machine should have one, or better still two series of change pinions. With these regulating pinions we can arrive, without guesswork, at the desired result.

We have just now given the proper draught when the roving is known; but as we do not employ new machines every day, we should know how to transform the numbers upon the machines actually in use.

Let us suppose that the yarn produced by the spinning frame is No. 40.

The rule to be followed is: *multiply the number of the teeth or the diameter of the change pinion by the number which is spun, and divide the product by the number of the yarn we desire to spin.*

1st Example.—With a change pinion of 45 teeth, we are spinning No. 40 yarn; what should be the number of teeth in the change or regulating pinion in order to spin No. 44?

$\frac{45 \times 40}{44} = 40.9 =$ the number of teeth of the change pinion.

2d Example.—The frame is spinning No. 44 with a change pinion of 41 teeth; what number of teeth in the new change pinion will be necessary to produce yarn No. 60?

$$\frac{44 \times 41}{60} = 30 \text{ teeth.}$$

Thus, by observing this formula in regulating the numbers of the spinning, we shall succeed in always being accurate; always, of course, supposing that the roving of preparation is regular.

I am aware that it is not always convenient to calculate in changing a pinion, as we often lack the time; I have therefore prepared a table from this formula, indicating the pinion corresponding to the yarn actually

spinning and that of the number to be spun, the use of which will be familiar after a few days' practice.

In order to use this table, look in one of the columns for the number of teeth of the pinion placed upon the frame. This is not always a whole number, and there will therefore be fractions; so that we find the nearest number, and following the same column, we stop opposite the number to be spun; the corresponding number will be that of the regulating pinion.

1st Example.—A frame spinning No. 40 has a pinion of 45 teeth; in which column shall we find the change pinion necessary to spin No. 44? In the first column, we find corresponding to No. 40 a pinion of 45 teeth; since we are looking for the change pinion of No. 44, we follow the column and find directly opposite No. 44 a pinion of 40.9 teeth, in other words 41 teeth, which is the one we require for the drawing. The difference of one-tenth of a tooth cannot, in any way, affect the result.

2d Example.—A frame spins No. 44 by means of a pinion of 41 teeth, and we desire to spin No. 60 yarn.

Corresponding with No. 44, a pinion of 41 teeth is placed in the first column. Following the column down to No. 60, we find a pinion of 30 teeth, which is the proper one to use for the draught.

Small fractions disappear by increasing or diminishing the teeth of the stud carrier by from 1 to 8, and in this manner the number can always be regulated.

Table showing the Number of Teeth of Change Pinions, for Numbers of Yarn between 10 *and* 90.

Numbers 10 to 90.

Numbers of the yarn.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.
10	60	62	64	66	68	70	72	74
11	54.6	56.4	58.2	60	61.8	63.6	65.4	67.3
12	50	51.7	53.3	55	56.7	58.3	60	61.7
13	46.1	47.7	49.2	50.8	52.3	53.8	55.4	56.9
14	42.9	44.3	45.7	47.1	48.6	50	51.4	52.9
15	40	41.3	42.7	44	45.3	46.7	48	49.3
16	37.5	38.7	40	41 2	42.5	43.7	45	46.2
17	35.3	36.5	37.7	38.6	40	41.2	42.3	43.5
18	33.3	34.4	35.6	36.7	37.8	38.9	40	41.1
19	31.6	32.6	33.7	34.7	35.8	36.8	37.9	38.9
20	30	31	32	33	34	35	36	37
21	28.6	29.5	30.4	31.4	32.4	33.3	34.3	35.2
22	27.3	28.2	29.1	30	30.9	31.3	32.7	33.6
23	26.1	27	27.8	28.7	29.6	30.4	31.3	32.2
24	25	25.8	26.7	27.5	28	29.2	30	30.8
25	24	24.8	25.6	26.4	27.2	28	28.8	29.6
26	23.1	23.8	24.6	25.4	26.1	26.9	27.7	28.6
27	22.2	23	23.7	24.4	25.2	25.9	26.7	27.4
28	21.4	22.1	22.8	23.6	24.0	25	25.7	26.2
29	20.7	21.4	22.1	22.8	23.4	24.1	24.8	25.5
30	20	20.7	21.3	22	22.7	23.3	24	24.7
Numbers 30 to 60.								
30	60	62	64	66	68	70	72	74
31	58.1	60	61.9	63.9	65.8	67.7	69.6	74.6
32	56.2	58.1	60	61.9	63.7	65.6	67.5	69.4
33	54.5	56.4	58.2	60	61.8	63.6	65.4	67.2
34	52.2	54.7	56.2	58.2	60	61.7	63.5	65.3
35	51.4	53.1	54.8	56.6	58.3	60	61.7	63.4
36	50	51.7	53.3	55	56.7	58.3	60	61.7
37	48.6	50.3	51.9	53.5	55.1	56.7	58.4	60
38	47.4	48.9	50.5	52.1	53.7	55.2	56.8	58.4
39	46.2	47.7	49.2	50.8	52.3	53.8	55.4	56.9
40	45	46.5	48	49 5	51	52.5	54	55.5
41	43.9	45.4	46.8	48.3	49.8	51.2	52.7	54.1
42	48.8	44.3	45.7	47.1	48.6	50	51.4	52.9
43	41.8	43.2	44.6	46	47.4	48.8	50.2	51.6
44	40.9	42.3	43.6	45	46.4	47.7	49.1	50.4
45	40	41.3	42.7	44	45.3	46.7	48	49.3
46	39.1	40.4	41.7	43	44.3	45.6	46.9	48.3
47	38.3	39.6	40.8	42.1	43.4	44.7	45.9	47.2

Numbers of the yarn.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.	Number of teeth.
48	37.5	38.7	40	41.2	42.5	43.7	45	46.2
49	36.7	37.9	39.2	40.4	41.6	42.8	44.1	45.3
50	36	37.2	38.2	39.6	40.8	42	43.2	44.4
51	35.3	36.5	37.6	38.8	40	41.2	42.3	43.5
52	34.6	35.8	36.9	38.1	39.2	40.4	41.4	42.7
53	34	35.1	36.2	37.3	38.5	39.6	40.7	41.9
54	33.3	34.4	35.6	36.7	37.8	38.9	40	41.1
55	32.7	33.8	34.9	36	37.1	38.2	39.3	40.4
56	32.1	33.2	34.3	35.3	36.4	37.5	38.6	39.6
57	31.6	32.6	33.7	34.7	35.8	36.8	37.9	38.9
58	31	32.1	33.1	34.1	35.2	36.2	37.2	38.3
59	30.5	31.5	32.5	33.6	34.6	35.6	36.6	37.6
60	30	31	32	33	34	35	36	37

Numbers 60 to 90.

60	90	91	92	93	94	95	96	97
61	88.5	89.5	90.5	91.7	92.4	93.4	94.4	95.4
62	87.1	88	89	90	90.9	91.9	92.9	93.9
63	85.7	86.7	87.6	88.6	89.5	90.5	91.4	92.4
64	84.3	85.3	86.2	87.2	88.1	89.1	90	90.9
65	83.1	84	84.9	85.8	86.7	87.7	88.6	89.5
66	81.8	82.7	83.6	84.5	85.4	86.4	87.3	88.2
67	80.6	81.5	82.5	83.3	84.2	85.1	86	86.8
68	79.4	80.3	81.1	82	82.9	83.8	84.7	85.6
69	78.2	79.1	80	80.8	81.7	82.6	83.5	84.3
70	77.1	78	78.8	79.7	80.6	81.4	82.5	83.1
71	76	76.9	77.7	78.6	79.4	80.3	81.1	82
72	75	75.8	76.7	77.5	78.3	79.2	80	80.8
73	74	74.8	75.6	76.4	77.2	78.1	78.9	79.7
74	73	73.8	74.6	75.4	76.2	77	77.8	78.6
75	72	72.8	73.6	74.4	75.2	76	76.4	77.6
76	71	71.8	72.6	73.4	74.2	75	75.8	76.6
77	70.1	70.9	71.7	72.5	73.2	74	74.8	75.6
78	69.2	70	70.8	71.5	72.3	73.1	73.8	74.6
79	68.3	69 1	69.9	70.6	71.4	72.1	72.9	73.7
80	67.5	68.2	69	69.7	70.5	71.2	72	72.7
81	66.7	67.4	68.4	68.9	69.6	70.4	71.1	71.8
82	65.8	66.6	67.3	68	68.8	69.5	70.2	71
83	65	65.8	66.5	67.2	67.9	68.7	70.4	70.1
84	64.2	65	65.7	66.4	67.1	67.8	68.6	69.3
85	63.5	64.2	64.9	65.6	66.3	67	67.8	68.5
86	62.8	63.5	64.2	64.8	65.6	66.3	67	67.7
87	62	62.7	63.4	64.1	64.8	65.5	66.2	66.9
88	61.3	62	62.7	63.4	64.1	64.7	65.4	66.1
89	60.6	61.3	62	62.7	63.4	64	64.7	65.4
90	60	60.7	61.3	62	62.7	63.3	64	64.7

Twisting.

The variety of fabrics which are supplied to commerce is very great. There are manufactures requiring yarns very much twisted, such as tapestry, fringe making, &c.; while there are others requiring loosely twisted yarns, of which the principal is hosiery. The amount of twisting varies then with each branch of industry, since it must be adapted to the products to be manufactured.

Twisting becomes irregular whenever the spindle bands grow old and greasy, as in that case they slide over the wharl.

All the frames of a spinning room should have the same running distance for all their carriages, and the spindles should make the same number of revolutions. 3500 revolutions is the most convenient number to obtain the greatest gain with little waste.

The spindle makes 31 revolutions for each turn of the crank.

In order to run the machines properly, we should be guided by the number of revolutions made by the crank at each winding up.

The greater or less number of revolutions corresponds to the twisting of the yarn; thus, the thinner the yarn becomes, the greater is the degree of twisting.

The degree of twisting may be changed at will, either through the intermediate grooved pulleys, or by the twisting pinion. In order to ascertain the true degree of twisting of the yarn, we follow this rule:—

Multiply the number of revolutions of the drawing roller by its circumference, and divide the number of revolutions of

the spindle by the product; the quotient will give the amount of twisting per unit of length chosen.

Example.— A drawing roller has a diameter of 25 millimetres, moves with a velocity of 100 revolutions per minute, and spins a number requiring that the velocity of the spindles be 3500 revolutions. What will be the degree of twisting per millimetre?

$25 \times 3.1416 \times 100 = 7$ metres 854 millimetres.

$\frac{3500}{7854} = 0.445$ twist per millimetre.

I know of no other more simple and certain method than the foregoing. We may say, then, that the quantity or product of the yarn is proportional to the degree of twisting. The following table gives the degrees of twisting proportionate to the numbers of yarn.

The first column indicates numbers of yarn, the second represents the corresponding numbers of revolutions of the crank; and in order to give a more exact idea as to the working of the machine, I have added a third column, in which is given the weight of yarn produced in twelve hours at the ordinary rate of running. Finally, the fourth column contains the corresponding numbers of revolutions of the spindles.

Table showing the Numbers of Yarn with the Degree of Torsion.

Numbers of the yarn.	Number of revolutions of the crank handle.	Weight produced in 12 hours.	Number of revolutions of the spindle.
10 to 12	16 to 18	35.0 kilog.	496 to 558
12 14		29.0	
14 16	17 19	25.0	527 589
16 18		22.3	
18 20	18 20	20.0	558 620
20 22		18.3	
22 24	19 21	16.7	589 651
24 26		15.5	
26 28	20 22	14.4	620 682
28 30		13.3	
30 32	21 23	12.5	651 713
32 34		11.2	
34 36	22 24	10.7	682 744
36 38		10.0	
38 40	23 25	9.5	713 775
40 42		9.0	
42 44	24 26	8.4	744 806
44 46		8.0	
46 48	25 27	7.7	775 837
48 50		7.3	
50 52	26 28	7.0	806 868
52 54		6.7	
54 56	27 29	6.4	837 899
56 58		6.2	
58 60	28 30	5.8	868 930
60 62		5.7	
62 64	29 31	5.5	899 961
64 66		5.4	
66 68	30 32	5.2	930 992
68 70		5.0	
70 72	31 33	4.8	961 1023
72 74		4.7	
74 76	32 34	4.5	992 1054
76 78		4.4	
78 80	33 35	4.3	1023 1085
80 82		4.2	

Operation of Spinning.

Three workmen are charged with the duty of arranging upon the creel as many roving ends as there are spindles, that is to say, that to supply 200 spindles, we need 100 spools of double roving, or 200 spools of one roving. The ends are passed through the funnel and under the top rollers. The spinner then makes a stretch with the machine empty, in order to bring out the drawn ends, and piece them to each of the yarns remaining upon the tube of the last taking off, after which he continues the operation.

As soon as a yarn breaks, the spinner or his associate hastens to the place where the break has occurred, and seizes either with his right or left hand, according to his particular custom, the spindle of the broken yarn above the wharl in order to stop it, and then looks for the broken end. Having found it, he passes it between the thumb and forefinger of the left hand while raising it, in order to detach enough to carry it beyond the drawing roller, and still holding the end between his fingers he pinches the top roller, disengages the barb (waste) which envelops it by a pulling motion, and lays the end of the yarn upon the extremity of the drawn roving; the junction is effected by twisting. The other details having been explained, we shall not recur to them.

Cleaning.

One of the conditions essential to the regular working of the spinning mule is, without doubt, the cleansing and oiling.

The spinner and his associate workman attend to the cleaning twice a day. We do not mean that the machine should be polished up, but that all bodies foreign to it should be removed.

The cleaning process consists simply in brushing the drawing rollers, and collecting the waste from the carriage. This is generally done a few minutes before leaving the spinning room. Sunday mornings a more complete cleaning takes place, and is begun upon:—

1st. The drawing and other rollers.

2d. The saddles.

3d. The under clearers.

4th. The gearing of the frame.

5th. The collars.

6th. The steps.

7th. And lastly the bands are examined.

A thorough overhandling and cleaning should take place twice a year. The oiling should be done regularly at stated hours. Some pieces require to be oiled oftener than others, such as the collars, the steps, and the levers. I have given some details in regard to oiling in the article on friction, to which I refer the reader.

Sampling or Proving.

Filamentous materials, such as spun wool, have very distinct degrees of coarseness, and it becomes necessary to estimate the fineness of each yarn numerically.

For this purpose, we employ a standard or number, which indicates either the length of a yarn in relation to a fixed weight, or weight in relation to a fixed length.

Thus, as a general standard, the following unit has been adopted:—

No. 1 represents a yarn, 1000 grammes (1 kilogramme) of which have a length of 1000 metres (1 kilometre). No. 2 indicates that the same weight has a length multiplied by 2, that is to say 2000 metres, or that a length of 1000 metres weighs a half less, or 500 grammes.

Thus, No. 100 has a length of 100,000 metres for the unit of 1000 grammes.

In the opposite direction of the scale, No. 2 indicates that 1000 grammes only give us a length of 500 metres.

This method of estimating is that adopted all over France for cottons, silks, and woollens. Flax and hemp are still numbered upon the English system.

In commerce, in order to facilitate the management of the hanks and samples, the steelyards are made so that the sample should weigh at the highest 50 grammes, that is to say, that No. 10 should weigh 50 grammes; for in these steelyards the unit is 500 grammes for 500 metres, which amounts to the same thing.

By multiplying the number of this scale by 2, we obtain the theoretical number.

Granting this, the weight in grammes of a hank (500 metres in length) of any number, will be obtained by dividing 500 by the number; and the number of a hank, the weight of which expressed in grammes is known, may be ascertained by dividing the number of metres by the weight.

1st Example.—What is the weight of a hank of 500 metres marking No. 27?

$$\frac{500}{27}=18.52 \text{ grammes.}$$

2d Example.—What is the weight of a hank of 250 metres marking No. 70?

$$\frac{250}{70}=3.57 \text{ grammes.}$$

3D EXAMPLE.—What is the number of a sample of 126 metres and weighing 4.5 grammes?

$$\frac{125}{4.5}=\text{No. } 27.77.$$

4TH EXAMPLE.—What is the number of a hank of 30 metres, weighing 2.5 grammes?

$$\frac{30}{2.5}=\text{No. } 12.$$

In order to follow closely and be properly guided as to the relations of numbers to weights, it would be well to consult the following table, which I have constructed to facilitate calculation, and, at the same time, avoid any inaccuracy which might be the result of mistakes in figuring.

Sampling is done by means of a reel 1 metre in circumference; and in order the better to ascertain the numerical value of the yarn, five bobbins should be procured with which a sample of 50 metres each is made, giving a total of 250 metres to be weighed upon the steelyard. The sample, by its weight, deflects the index toward a number which is to be divided by 2, and the quotient will give the real number, because the sample is only 250 metres long, whereas for these scales it should be 500 metres.

EXAMPLE.—5 bobbins give upon the reel 250 metres, which are hooked to the steelyard, or quadrant, to ascertain the number, and the index is deflected to No. 80. What is the real number?

$$\frac{80}{2}=\text{No. } 40.$$

Table showing the Numbers of Yarn with the corresponding Lengths and Weights.

Numbers for 500 metres.	Numbers for 250 metres.	Numbers for 100 metres.	Corresponding weights expressed in grammes.*	Numbers for 500 metres.	Numbers for 250 metres.	Numbers for 100 metres.	Corresponding weights expressed in grammes.
1			500.00	46	23		10.87
2	1		250.00	47			10.64
3			166.67	48	24		10.41
4	2		125.00	49			10.20
5		1	100.00	50	25	10	10.00
6	3		83.33	51			9.80
7			71.43	52	26		9.62
8	4		62.40	53			9.43
9			55.55	54	27		9.26
10	5	2	50.00	55		11	9.09
11			45.90	56	28		8.93
12	6		41.66	57			8.77
13			38.46	58	29		8.62
14	7		35.71	59			8.47
15		3	33.33	60	30	12	8.33
16	8		31.25	61			8.19
17			29.41	62	31		8.06
18	9		27.78	63			7.94
19			26.30	64	32		7.81
20	10	4	25.00	65		13	7.69
21			23.81	66	33		7.57
22	11		22.73	67			7.46
23			21.74	68	34		7.39
24	12		20.83	69			7.24
25		5	20.00	70	35	14	7.14
26	13		19.23	71			7.04
27			18.52	72	36		6.94
28	14		17.86	73			6.85
29			17.24	74	37		6.75
30	15	6	16.67	75		15	6.66
31			16.13	76	38		6.57
32	16		15.62	77			6.49
33			15.15	78	39		6.41
34	17		14.71	79			6.33
35		7	14.29	80	40	16	6.25
36	18		13.89	81			6.17
37			13.51	82	41		6.10
38	19		13.16	83			6.02
39			12.82	84	42		5.93
40	20	8	12 50	85		17	5.88
41			12.19	86	43		5.81
42	21		11.90	87			5.74
43			11.63	88	44		5.68
44	22		11.35	89			5.62
45		9	11.11	90	45	18	5.55

This table gives at a glance the necessary information for sampling.

To simplify these calculations, and as it were to frame all these operations by one instrument, I have sought out a system which would give both the number of the yarn, the weight, the number of the preparation, and the corresponding draught. For this purpose, I have made use of the ordinary scale, and have indicated everything in figures as will be seen.

Mr. Piat's quadrant scale has only one circle to indicate the numbers of the yarn; to this scale I have added three other columns.

The first column, as usual, indicates the numbers; the second, the corresponding weight of the sample.

The sampling of the yarn is conducted on the standard length of 500 metres, or indeed 250 metres to avoid loss, as will be seen further on.

We shall take the basis of a length of 500 metres, which, for greater regularity, are taken from five different bobbins. If this sample is submitted to the scale improved by me, the index will turn to a number which will be that of the yarn. In the second column will be found the weight of the same sample, which may be a convenience in many cases.

The third column will indicate the number of the preparation necessary to produce a given yarn. The sliver of prepared wool should always be 50 metres in length.

If, for instance, we wish to make No. 20, the sliver suspended to the scale should mark No. $2^{p.}$, corresponding to No. 20 of yarn, and as I suppose a draught of 10, it is equally easy to ascertain the draught; for if, for example, the index needle stopped at 3 degrees beyond No. 2, the draught would be $10+3=13$; and if, on the contrary, it stopped at 3 degrees before, the draught should be $10—3=7$.

Each number of preparation is divided into 10, in order to indicate the various draughts, as in the following table:—

Table giving the Numbers of Yarn with their Weights, and the corresponding Slivers.

Numbers of the yarn.	Corresponding weights, grammes.	Numbers of the slivers.	Numbers of the yarn.	Corresponding weights, grammes.	Numbers of the slivers.	Numbers of the yarn.	Corresponding weights, grammes.	Numbers of the slivers.
1	500.00		35	14.29		69	7.24	
2	250.00		36	13.89		70	7.14	—
3	166.67		37	13.51		71	7.04	
4	125.00		38	13.16		72	6.94	
5	100.00		39	12.82		73	6.85	
6	83.33		40	12.50	—	74	6.75	
7	71.43		41	12.19		75	6.66	unit 7.
8	62.40		42	11.90		76	6.57	
9	55.55		43	11.63		77	6.49	
10	50.00	—	44	11.35		78	6.41	
11	45.90		45	11.11	unit 4.	79	6.33	
12	41.66		46	10.87		80	6.25	—
13	38.46		47	10.64		81	6.17	
14	35.71		48	10.41		82	6.10	
15	33.33	unit 1.	49	10.20		83	6.02	
16	31.25		50	10.00	—	84	5.95	
17	29.41		51	9.80		85	5.88	unit 8.
18	27.78		52	9.62		86	5.81	
19	26.30		53	9.43		87	5.74	
20	25.00	—	54	9.26		88	5.68	
21	23.81		55	9.09	unit 5.	89	5.62	
22	22.73		56	8.93		90	5.55	—
23	21.74		57	8.77		91	5.49	
24	20.83		58	8.62		92	5.43	
25	20.00	unit 2.	59	8.47		93	5.38	
26	19.23		60	8.33	—	94	5.32	
27	18.52		61	8.19		95	5.26	unit 9.
28	17.86		62	8.06		96	5.20	
29	17.24		63	7.94		97	5.15	
30	16.67	—	64	7.81		98	5.10	
31	16.13		65	7.69	unit 6.	99	5.05	—
32	15.62	unit 3.	66	7.57		100	5.00	unit 10.
33	15.15		67	7.46				
34	14.71		68	7.39				

The following are applications of this scale:—

Having No. 40 to manufacture with a sliver marking in the column of slivers 4.5, it will be necessary to make the draught 10—5=5. It is rare that the slivers require only a draught of 5; generally the draught varies from 5 to 15.

Take another example:—

Having a sliver to make into No. 40, which marks on the scale No. 3.6, and since 4 is the nearest whole number, the draught will be 10+4=14.

In the following report allusion is made to English yarn, but as our own industry has no longer anything to dread from this source, I shall not dwell upon it here.

SOCIÉTÉ IMPÉRIALE D'ÉMULATION D'ABBEVILLE.

Session of April 7th, 1859.

Report of Mr. E. Pannier, Vice-President, upon the quadrant scale of Mr. Charles Leroux.

"Our compatriot Mr. Charles Leroux, wool spinner at Hangest-sur-Somme, whom I have already had the honor of mentioning in connection with an index level invented by him, has begged me to communicate to you the improvements which he has just made upon the scales used in the manufacture and sale of yarns and threads.

"But before indicating these improvements, I think it best to enter into some details, which will assist you in understanding the explanation which I shall give.

"Yarns, of whatever nature they may be, are designated by numbers which indicate their degrees of fineness. The finer the yarns are, the higher is the number;

thus, for instance, No. 100 is finer than No. 80, No. 60 than No. 50, and so on.

"In classifying yarns, we make use of a quadrant scale, composed of the arc of a circle made of metal and placed vertically, of an index suspended at the central point upon a movable axis, and of a lever continuous with the index at its point of suspension; the arc also bears divisions corresponding to a series of figures.

"Whenever we wish to determine the number of any given yarn by this instrument, a sample having a known length is hung upon the lever; the index, thus drawn upon by the weight, ceases to be vertical, and rests upon one of the divisions of the circle; the figure corresponding to that division indicates the number of the yarn. But this figure represents only the number of the English manufacture, and has no relation to the weights and measures used in France.

"This method of estimation, which was necessarily used while France was tributary to England in what are known as machine made yarns, is at the present day an anomaly which it behooves us to abolish, not only because French spinning is more than sufficient for our consumption, but because it stands all competition with advantage, and should properly have, as it deserves, a designating system of its own corresponding with our weights and measures.

"This is not the only modification which Mr. Leroux has made in the instrument we are considering. While still preserving the external form, he has divided the surface of the arc by concentric lines indicating simultaneously the French number, the corresponding English

number, the weight of the sample in grammes, and finally the number of the preparation.

"The diameter of the yarns having a direct relation to their length, since with an equal weight a sample of fine yarn contains more metres than a sample of coarse, Mr. Leroux has adopted 500 metres as a fixed length for the samples; so that in hanging one of such samples on the lever, the index will stop on one of the rows of figures superposed upon the arc of the circle, and will give at once the French number, the English number, and the weight of the sample. This last indication is most precious to the manufacturer who can thus, at a glance, ascertain exactly the result of the raw materials brought for manufacture.

"It remains for me to explain the use of the fourth division of the circle (the preparation numbers).

"Suppose, in an actual state of things, that a manufacturer wishes to make a certain number, it will be necessary for him to choose with care the preparation which shall appear to him capable of giving the desired result. He will then have to try the amount of draught and twisting to be given to the preparation, all of which will entail the repeated changing of pinions, and necessitate experiments and loss of time.

"With the improved scales, these inconveniences disappear. It will be remarked that each one of the great divisions, 1, 2, 3, &c., of the preparations corresponds with the numbers 10, 20, 30 of the French yarn, and that each of these divisions is itself subdivided into 10 parts. This settled, it will then be sufficient, in order to obtain any given coarseness of yarn, say No. 20, to suspend 50 metres of a preparation approximatively chosen; we may

then have three results: either the index will stop exactly at No. 20 of the yarn corresponding to No. 2 of the preparation, or it will pass by that number, or it will fall short of it.

"In the first case, the draught should be 10 times the length of the sliver of preparation experimented upon, as each one of the French numbers supposes a draught of 10. On the other hand, if the index goes beyond No. 2 by a certain number of subdivisions, say 3, the draught should be 10+3=13; and finally, if it does not attain the number by that amount, the draught will be 10—3=7. It may indeed be easily understood that, the lighter the sliver we are trying is, the less material it contains, and therefore should be less drawn out in order to produce a desired result, and we can appreciate the advantages of this instrument, which leads without error to the result at which we aim.

"I do not know whether Mr. Leroux desires to take out a patent for this system, which appears to unite all desirable conditions, but I think that it would be proper to file this report, incomplete though it be, among the records of this day's proceedings, in order to preserve a priority to the inventor which might be useful to him."

Abbeville, April 7th, 1859.

Signed, E. PANNIER.

A true copy:—

The President of the Société Impériale d'Émulation.

Signed, J. BOUCHER DE PERTHES.

PART III.

CHAPTER I.

THE ENGLISH METHOD OF SPINNING.

The Drawing Processes.

The methods used in England for the spinning of wool do not resemble those employed in France in any particular. The preliminary operations are generally performed by means of breakers with three main cylinders. Each breaker is provided at its head with an arrangement of combs, or with any other system. For some time, an arrangement for spooling has been used, and thus the workman can proceed in the same manner as in the French system. The carded sliver passes through the comb, which straightens the fibres. This sliver falls into a can.

This kind of carding constitutes a branch of industry known in France as card combing; for, when wool of any kind is to be submitted to the process of combing, it becomes useless to subject it to carding with three main cylinders, which would evidently injure the material.

The combing is carried on in the same way as with us. There are in England many kinds of combing apparatus established on the systems of Lister and Holden, Donisthorpe, Ramsbotham and Brown, &c.

Generally speaking, the combing is performed on oiled materials, for which I shall assign a reason further on.

FIRST PASSAGE.

As soon as the slivers leave the breaker, or the combing machine, they are submitted to the gill-box, or arranged behind that machine, which is provided with two spindles (16 cans). The machine we have described for the French method has no spindles, but here all the preparations are twisted.

The gill-box is provided first with an iron reservoir placed in advance of the feed rollers, passing underneath the machine, and receiving a current of steam in its interior; by this means, the slivers are softened while passing over the heated portions, and disposed to be readily drawn out. Tho oil being uniformly distributed over the surface of the wool prevents the breaks occasioned by unoiled fibres.

Thus, as we see, the slivers become warmed, and pass between three iron rollers with coarse round flutes serving as feed rollers. On leaving these rollers, the hackle bars armed with two or three rows of pins, according to the degree of fineness of the wool, conduct the material to the drawing roller. This roller, moving with a velocity four or six times that of the gills or combs, pulls the wool off the latter with all possible regularity, and forms two slivers reduced from their original volume by as many times as this cylinder has developed greater speed, relatively to that of the combs and feed rollers. These reduced slivers then become twisted by winding off upon two bobbins set in motion by the two spindles. Each

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sliver passes into the tube of the fly and into the ring of one of its branches, in order to be rolled off upon the bobbin.

Each bobbin receives its motion, either from wheel gear, or belts; and the velocity is regulated by a torsion pinion. There is a traversing rail regulating the direction, and screw springs to act as checks and insure regularity in the pressure of the twisted slivers.

In beginning a spool, the checks are slightly tightened, and then gradually loosened until the end of the winding, after which the spools are laid aside.

Sampling (proving) the Preparations.

Each spool should be sampled, and for this purpose we take 10 metres of the preparation. It would be very inconvenient to measure with a metre rule, and therefore we proceed differently by means of a little instrument, the structure of which is as follows: A small wooden drum, having a diameter of $0.^{m.}333$, is supported by two cast iron uprights, and its axle revolves in brasses fixed to the uprights. One end of the axle is supplied with a crank handle, by which it can be turned. Each upright is provided with a slide, and between these two slides is a small roller placed so as to rest upon the drum, and follow the motion of the latter. Opposite the exit from this little cylinder is a small and sensitive weighing apparatus to receive the sliver to be sampled.

In the first place, we unroll a certain amount of sliver without cutting it, and pass this sliver under the top roller; then we turn 10 times making 10 metres, the sliver descends into the pan of the scale, and the index shows the corresponding weight. The top roller is taken

off, and the sampled sliver wound again upon the bobbin. The foreman having charge of this work labels the plate of the bobbin with the number indicated by the scale.

These spools are arranged in the order of their numbers or weights. Thus, in order to make a variety of numbers, it is necessary to make spools on the gill-box, which will not all indicate the same weight; for, the finer the numbers are, the thinner the slivers become, and conversely for the coarse numbers. Still, in this first passage, the differences of weight are not so great as one would think, and the subsequent draughts correct the irregularities.

Table showing the Weights of Slivers corresponding to the Numbers to be Spun.

Weights of slivers (10 metres in length).	Numbers of the yarn.	Draughts at the second passage.	Number of slivers for doubling.
48 grammes.	10	from 1 to 4	3
47	15		
46	20		
45	25		
44	30	from 1 to 5	3
43	35		
42	40		
41	45		
40	50	from 1 to 6	4
39	55		
38	60		
37	65		
36	70	from 1 to 7	4
35	75		
34	80		
33	85		
32	90	from 1 to 8	4
31	95		
30	100		

The numbering given above is metric.

Weighing of the Preparations.

In order to throw more light upon our subject, we shall work each of the preparatory machines in succession. We shall thus become more familiar with the details, and be the better able to appreciate the advantages which might accrue from them to French industry.

Let us suppose that we have to treat No. 40 upon these machines. As we have said that the gill-box produces spools, and that their weight can be regulated, this weight should be fixed at 42 grammes for a sample of 10 metres, and 3 slivers in the doubling, in order to produce this number.

It is difficult to obtain perfect regularity in the first passage, for the twisted slivers vary in weight.

As has been said, the spools are arranged in the order of their weight, and thus we will suppose them to weigh 40, 41, 42, 43, 44 grammes for 10 metres. Since we have to double with 3 slivers, we choose spools giving by addition $3 \times 42 = 126$.

44	44	43	41
40	41	40	43
42	41	43	42
126	126	126	126

So that notwithstanding the difference in weight, we can form the unit which is 126 grammes for this number.

SECOND PASSAGE.

The machine intended for the second passage has no gills. Behind the frame is placed the creel to support the prepared products of the first passage.

Instead of gills, we have smooth rollers surmounted by small top rollers of iron or wood, as the makers may prefer. The three slivers first pass between two feed rollers, thence between two pairs of rollers, and finally between the drawing rollers.

The twisted slivers become flattened between the first, which evidently disposes them to untwist; then comes the top roller near the drawing roller, which prevents the sliver from untwisting too freely; lastly, the drawing roller draws out the sliver, and, untwisting it, delivers it to the spindle, which retwists it to form the spool, which will be of less weight than that of the first passage. The draught is calculated upon the same principle as in the case of other methods.

If the draught of the machine is 4, we shall have spools weighing $\frac{126}{4}=31.5$ grammes for 10 metres of sample.

The twist is regulated in the same manner. This machine, like the preceding, has two heads or two spindles.

THIRD PASSAGE.

This machine resembles the preceding, except that it possesses 4 spindles instead of 2. These spindles are smaller than the former, but are regulated in the same manner. The spools proceeding from the second passage we have supposed to weigh 31.5 grammes. At this passage, the doubling is effected by 3 slivers, or $31.5\times 3=94.5$ grammes; and the draught being 5, we shall have:—

$$\frac{94.5}{5}=18.9 \text{ grammes.}$$

The twisting increases with the degree of fineness of the preparation.

The bobbin can be readily removed from the spindle on account of the peculiar construction of the latter. This spindle is fast with the flyer. The head of the spindle acts as a journal in a collar, the opening into which is made by means of a spring button.

The pivot of the spindle is flat, broad, and enters into a notch made in the centre of the torsion pulley, so that, by these means, the spindle may be withdrawn at will to put on or remove the bobbin.

Here, the tension of the spool is always the same, for there is no check. It is evidently a great mistake not to adopt some means of regulating the tension.

FOURTH PASSAGE.

This machine is similar in construction to the preceding, except that instead of 4 spindles, it has 6.

The tension of the spool is obtained by means of a disk of felt (cloth washer) placed upon the plate bolster. The plate of the bobbin turns upon this disk.

As in the other machines of this series, the drawing roller is fluted, and has in this instance a diameter of 6 centimetres.

Each drawing roller is surmounted by a top roller, made of cast iron, and covered first with cloth, and outside of that with calf-skin.

These top rollers move in slides upon the uprights of the machines. The pressure may be varied at pleasure by means of spring and screw caps.

We have already said that the preparation obtained at

the third passage weighed 18.9 grammes. We double at this passage by two slivers, which gives $18.9 \times 2 = 37.8$; and the draught being 4, we shall have:—

$$\frac{37.8}{4} = 9.45 \text{ grammes.}$$

The velocity of all these machines is regulated so that they shall supply each other.

FIFTH PASSAGE.

As is the case with all systems, the nearer we approach the spinning process, the smaller the spools become, and the finer the preparation.

In this case, the machine giving the fifth passage, which is the one next before the last, is composed of eight spindles.

However well the wool may have been scoured before the carding or combing, it still very often retains impurities after these operations, either from the oiling, or on account of knots or dirt. The drawing rollers, under a strong pressure, carry off these impurities and lodge them on the felts of the top clearers; the top clearers are therefore as necessary in this instance as in that of all other systems.

When a sliver breaks during the work, it will not be sufficient, as in the French system, to weld the two ends together by rubbing, but we must plait them together, in order that the sliver may be prevented from escaping during the process of drawing. In the case of breakage, the yarn is apt to be marked by points, or swellings, which constitute a defect in the English method.

The preparation on leaving the fourth passage marked

9.45 grammes; now, the doubling in this case is by two slivers, and we shall have $9.45 \times 2 = 18.90$ grammes. The draught is 3, which gives $\frac{18.90}{3} = 6.3$ grammes for the preparation of the fifth passage.

SIXTH PASSAGE.

Before subjecting the spools coming from the preceding passage to this new machine, which like the last has 8 spindles, we sample or prove the sliver, in order to regulate the sixth passage, and obtain a preparation susceptible of being spun readily and without great loss.

If it is necessary to make No. 40, which we have chosen for the spinning frame, with a preparation capable of being drawn out from 5 to 20, the roving ought to weigh about 3 grammes for a length of 10 metres.

Knowing that the sliver of the fifth passage weighs 6.3 grammes, we must so arrange the draught of the last roving frame that the roving may not be over 3 to 4 grammes. The doubling being by 2, we have $6.3 \times 2 = 12.6$ grammes, and we arrange a draught of 4.2 so as to obtain $\frac{12.6}{4.2} = 3$ grammes.

Instead of sampling by 10 metres, we may do it with 25, which will facilitate the operation and give less chance for error, especially if we use the improved scale.

When it is desired to ascertain the draught necessary to produce a given roving at the last passage, *divide the weight of the two slivers derived from the fifth passage by the required weight, and the quotient will give the desired result.*

Example.—Two slivers, together, weigh 12.6 grammes, and we wish to make a roving weighing 3 grammes, what will be the proper draught?

$$\frac{12.6}{3}=4.2=\text{the draught.}$$

Too great a degree of twisting is not desirable, but enough is required for the roving to unroll properly upon the spinning frame.

A series of preparatory machines, arranged in this manner, may produce in 12 hours 100 kilogrammes of No. 20.

Each machine is driven by a coupling gear; and all the spindles are upon a same line, with space enough to pass the bobbins.

When a breakage occurs among the slivers during the draught, the entire machine should be stopped, for it is very dangerous to put the hand into the machinery while in operation, as it is generally very high.

The distance between the feed and drawing rollers varies very little, and is from 25 to 40 centimetres.

All the preparations from the sixth and last passage are carried to the spinning-room.

CHAPTER II.

ENGLISH METHOD OF SPINNING CONTINUED.

Arrangement of the Spinning Frame (Throstle).

The frame we are about to use for spinning the prepared and twisted roving is an English machine, and greatly resembles in form the flax spinning frame of Decoster.

The spindles are vertical, and rest upon a plate bolster (step-rail), furnished with as many steps as there are spindles. A second plate bolster is fixed above the wharls. Each spindle is supplied with an immovable brass collar, and cannot be withdrawn without unfastening this plate bolster.

Each spindle possesses a flyer with a curl at the extremities of its branches. Between the step-rail and the flyer, another traversing rail is worked up and down through the intervention of a heart-shaped eccentric.

The frame, from the drawing roller to the summit is roof shaped; it has a series of grooved rollers above the fly at the angle of the frame; besides, we find several other similar rows of rollers, among which is the one for supplying the twisted roving, and which is surmounted by small top rollers.

The pressure is obtained by means, either of weights, or springs; but the top rollers between the feed and

drawing rollers are light and not weighted, their own weight varying from 100 to 150 grammes. The top roller, which is to produce the draught, is generally made of wood, and has a diameter of 8 to 12 centimetres. Each pair of rollers is traversed by a turned axle, the two ends of which revolve between two small slides arranged for the purpose; between these two rollers is a small bearing acted upon by a spring.

For fear of making the frame too heavy, the surfaces of the saddles are not made large. By this means we lose a quantity of waste fourfold in value that of the power economized. In this case, there should be a double saddle, maintaining the two axles of the pair of rollers, which saddle should be retained in position by a lever and weights, for it often happens that one side of the roller will press more forcibly than the other.

The driving gear is placed at one end of the machine, and drives the drum and the gearing of the rollers. The spindles are driven by the drum on each side; for the frame is double, having 64 spindles on each side

Intervals.

The intervals are variable as in the other machines. They vary from 15 to 25 centimetres, and are subordinated to the length of the wool and its degree of torsion. Too short an interval produces lumps and irregularities, for the roving has not length enough to untwist. If, on the other hand, the intervals are too great, the roving becomes distorted, untwists irregularly, and produces a bad yarn.

The following intervals may be employed with advantage. They are calculated by the length of the staple.

Lengths of the Fibres.	Intervals.
6 centimetres.	from 15 to 17 centimetres.
8 "	" 18 to 20 "
10 "	" 20 to 22 "
12 "	" 22 to 24 "
14 "	" 24 to 26 "
16 "	" 26 to 28 "
18 "	" 28 to 30 "

Top Rollers.

As we have said, the top rollers should be so arranged as to spin all materials without inequalities. The top rollers for feed rollers are of cast iron, covered over with good leather, glued on. Those which follow are of iron. These rollers should have a different density for each row or height, for the untwisting is effected gradually; and I believe that this means is not without some value. The large top rollers of the drawing rollers are made of turned wood, covered over first with felt and then with leather. They become quickly soiled, when the wools are dirty and oiled with a bad material. The operator should clean the frame twice a day.

Tensions.

In beginning to work with a spinning frame, the spinner should first oil it, and then arrange on the creel a number of spools equal to that of the spindles. She

then passes the ends between the rollers, and stops the machine in order to make the attachment with the bobbins left from the previous batch. This she does in the case of each bobbin. She breaks an end of the service bobbin, makes the piecings, and then sets her machine in motion. But, in order that the little bobbins of the spindles should produce the proper tension, which should depend upon the quality of the yarn and the size of the bobbin, there is fixed upon the traversing rail, at each bobbin, a small cord to which is attached a weight, and which by its tension serves to press the neck at the base of the bobbin. The bobbin is thus more or less free to turn, and in this manner regulates the tension at will.

Twisting.

The twist is produced by a change pinion, which retards the progress of the drawn-out material.

The velocity of the spindles is 3000 revolutions in a minute for good wools, and 2500 for inferior qualities. Too high a velocity produces a curling up of the yarn.

The degree of twist is calculated in the same manner as for the mule. We should observe here that it is easier to make strongly-twisted numbers upon the throstle frame than upon the mule. Yarn No. 100 is rarely made upon the former, and even then with greater difficulty and less regularity than upon the mule.

The coarse numbers of long wool, however, are readily spun upon the English frame, and I even believe that the making of coarse numbers is thus rendered cheaper than by the use of the mule.

With No. 15, English wool, one workwoman can take

charge of 128 spindles, in other words, of two sides of a frame; for the frames are so placed as to enable her to attend two sides, either by putting them in a line, or opposite each other. In the latter arrangement, she has less running to do, but, at the same time, cannot see what may be taking place behind her.

The piecing of broken yarns is made while the machine is in motion. As soon as a yarn breaks, the woman stops the spindle with her left hand by means of the fly, and searches for the broken end with her right; she unrolls it and passes it at once between the thumb and forefinger of her left hand. Then with the right hand she disengages the barb from the top roller, unites the two ends of the yarn which become twisted, and restores the yarn.

Draughts.

The draught is regulated in this machine in the same manner as in the mule. It varies from 1 to 20, and more if we desire; but it is imprudent to endeavor to carry the draught too far, for we run the risk of making a very poor and irregular yarn. In this particular we should always be guided by the nature of the material; for, while one wool may be drawn out to the extent of 20 without inconvenience, another sample will with difficulty be brought as far as 8. This difficulty exists with wools of different lengths; so that in this kind of frame it is best to select wools of the same length.

Short wools act very badly with throstle frames, unless some modification is introduced in the construction of these machines.

Generally speaking, short wools are difficult to draw out, with or without twist.

We have said that the roving weighs 3 grammes for every 10 metres, which is equal to No. 3.33 of the preparation.

To obtain the necessary draught, *divide the number to be spun by the number of the preparation, and the quotient will be the draught.*

EXAMPLE.—Wishing to make No. 40 with a roving weighing 3 grammes for 10 metres, or in other words, the number 3.33, what will be the draught?

$$\frac{40}{3.33}=12=\text{the draught.}$$

The bobbins should not be too full, lest they should produce irregularities in the yarn, that is to say, lest they should stop between the eyes. Instead of stopping the machine during the taking off, it may be allowed to remain in motion.

CLEANING AND OILING THE MACHINE.

The workwoman, some minutes before leaving the spinning-room, cleans the top rollers and the collars. For the steps, this work should be performed every week, on Sunday mornings. The woman cleans the frame, and the bearings, and sees that the spindle bands are all uniformly tense. The foreman should himself look particularly after this operation.

On Monday morning, when the machines are again set to working, all the movable parts should be oiled; the bearings and the top rollers once, and the collars twice a day.

CHAPTER III.

FRENCH SPINNING ON THE THROSTLE.

Preparations for the Throstle Frame.

The prepared slivers coming from the last drawing frame are carried to a frame having 8 spindles. This machine is constructed in about the same manner as that used in the English system.

In this case the creel is not arranged like those for holding the spools horizontally. The spools move standing, and the slivers are carried on by calender rollers. They then pass under top rollers, the pressure of which does not crush them. Thus, as it may be seen, the whole preparation, as in the case of the mule, is carried on with flat slivers passing over combs. After leaving the preparatory machines, the spools of back washed wool are sampled, in order to convert them into twisted roving upon the roving frame of 8 spindles.

I would here remark that the intervals upon this machine are less than in the case of the preparatory machines of the English system, for the combs placed here, instead of the first conductor, hold the wool and form a much more regular roving than that obtained by simple pressure of top rollers.

The intervals vary from 10 to 22 centimetres.

All the prepared wool thus twisted is submitted to the spinning frame.

Spinning Frame (Throstle).

In the French system, the English throstle frame is adopted in treating the prepared wool. The operation is the same, and it would therefore be useless to speak of it any further.

Comparison of the Systems of Spinning.

I have for several years conducted the spinning of wool both oiled and unoiled, by the English and French systems.

I have recognized the fact that throstle spinning, when carried on with twisted and oiled preparations, produced considerable waste and irregular yarns; whereas, the system of throstle spinning with unoiled materials, that is to say, by first combing the wool and passing it through drawing frames, and then through a roving frame having combs and movable intervals, gave handsome results when compared with the English system of untwisting. I believe that we may come to work very well with the throstle frames, but I repeat it, they need reconstruction and modification; for up to the present time none of these spinning frames can rival the spinning mule, which was indeed born in England, but which was abandoned there for a poorer system.

Doubling (Twining).

Doubled yarn enters into the manufacture of French fabrics in the proportion of one-sixth. This estimate

shows how important this branch of industry is, and that it well deserves briefly to engage our attention.

These doubled yarns are principally used in the following manufactures: Tapestry, Fringes, Woollen Velvet, Hosiery, Shawls, Twilled Taffeta, Open Work Fabrics.

Each one of these manufactures employs a special twisting of two, three, or four yarns.

Doubling on the Mule (Twining, Doubling Mule.)

Usually, doubling is effected by means of the mule, the top rollers of which have no drawing action.

In this system we arrange as many bobbins as we have ends to double, upon small iron spindles fixed horizontally in a vertical plate, so that each spindle receives a bobbin. The woman charged with this work is supplied with an ordinary spooling wheel furnished with a wooden bobbin, and upon this bobbin she winds the yarns while uniting them. These bobbins are fitted to produce a doubling yarn. In this spooling, care should be had that the yarns are always stretched so as to be parallel.

These bobbins are placed behind the creel in making a doubled yarn rolled upon tubes; but when wooden bobbins are used, they can be very easily worked upon the ordinary creel.

The winding up is performed as usual. The doubling is also effected upon self-acting mules; these machines accomplish a great deal of work.

Doubling on the Throstle Frame.

The doubling throstle frame used for woollen yarn is made of cast iron, and has horizontal spindles, each side

bearing 48. The creel varies according to the kind of bobbins to be unwound. For instance, if we are using bobbins with heads from the spinning throstle, the creel will hold its spindles with their heads upwards; but, on the other hand, if we are working with paper tubes (sluffs) then the spindles will be arranged upon a plate or frame, so that their heads will be downwards; by these means the bobbins will unwind without waste. The yarns from each bobbin pass through a curl. There, as many yarns are united as we desire to double, and are then wound (one turn only) around a cast-iron roller, which serves to maintain and regulate the progress of the doubled yarn according to the desired torsion. These rollers rest upon a long shaft, at the end of which is fixed a wheel of 135 teeth, and even more, which receives its motion from a change pinion connected with a pulley, driven by another pulley fixed at the extremity of the drum. The drum turns the spindles by means of bands which pass over wharls placed at the extremity of the spindles. Each head of spindle is tube shaped, and this tube receives the yarn. It is readily seen how the spindle in turning will cover with yarn the bobbin, which goes up and down by means of a heart-shaped eccentric producing the motion.

There are four stop motions, or, in other words, 24 spindles may be stopped simultaneously, which is obviously very convenient for the workwoman, and consequently is more productive than in the case of one disengaging gear only.

To obtain extra fine yarns, the number of spindles may be carried as high as 140.

On a frame with 96 spindles and 4 disengaging gears

(stop motions), three yarns of No. 20, with a twist of one turn to the millimetre, may be spun at the rate of a kilogramme to each spindle.

As soon as the yarns are doubled, they are carried to the winding apparatus.

Winding.

In winding doubled yarns, the bobbins are placed upon the spindles of a large winding reel with a capacity of 40 bobbins, which is driven either by hand or machinery. With machinery, a woman can take charge of 80 bobbins, for the reel is made to move more slowly than when driven by hand, and the spindles are taken off by 4 divisions, as in the Milner machine.

Winding reels have circumferences adapted to different branches of industry, but I am very partial to that of 2 metres, as a standard for circumference.

Each reel should be supplied with a counter which stops at every 100 revolutions, giving 200 metres to a hank. This reel gets automatically out of gear every 100 revolutions, as is the case in many manufactures.

At every stoppage the workwoman ties the hanks with a thread of cotton or some other material, and they are carried over to be twisted.

Twisting the Hanks.

The operation consists in hooking several hanks upon a V-shaped pin, and giving them a twist by means of another straight pin held in the hand, thus interlacing

them so as to produce a twisted hank all ready for transportation. This is done in the case of doubled yarn.

Packing.

After the yarn leaves the drying rooms it is packed. If the material has been well dried and stretched, it should curl very little. A table is arranged with iron pins to hold the heads of the hanks, and the process is carried on as follows:—

A workman begins by tying two hanks at one end, and thus places three between the two rows of pins which are to receive the yarn. Then he engages the head of a hank in the V shaped instrument and twists it; after which he carries off his hank, engaging it in two pins, and by continuing this process the packing is effected. It only remains to tie this to the other hanks already arranged upon the table, and to withdraw the package from the pins.

Baling.

The store-rooms, in which the yarns and prepared wools are kept, ought to be sheltered from the direct action of the sun and of too great heat.

The yarns coming from the spinning mill are carried into these store-rooms, and kept there until they are delivered out. It is absolutely necessary that the yarn should regain what it has lost during the treatment; the loss varies from 1½ to 3 per cent., because there is always a difference between the weights given by the scale in the workrooms, and those given by the scales in the

store-rooms. During spinning, the temperature being kept at 20° Centigrade, it is evident that the yarn has lost part of its normal weight; whereas, in the store-rooms of the first floor, where the light is admitted sparingly, the temperature is lower, and the wool regains its normal hygrometric state.

When a delivery is to be made, the interior of the packing box or crate is lined with a strong tarred paper. It would be advantageous if some paper manufacturer could be induced to incorporate sulphur into the paper pulp; by this means, the yarn would no longer be cut by worms. The bobbins are spread out by layers.

PART IV.

CHAPTER I.

CARDED WOOL.

Glance at this Kind of Manufacture.

The same as with combed materials, the wools which we desire to convert into yarn by the processes of carding and spinning are first sorted, scoured, cleaned, opened, and carded into a continuous roving, to be afterwards spun upon the mule or the throstle frame.

We see that in all the methods of spinning the throstle frame appears as taking the place of the frame with alternate motion. Repeated attempts have failed for producing simply carded wool. The only frame, which at the present time has succeeded in properly spinning carded wool, is the throstle frame of Mr. Vimont, of Vire. We will speak of it hereafter ; but we have now to exclusively occupy ourselves with the mule working oiled materials.

Preparations of Wools—How They are Used and Sorted.

It is unnecessary to repeat here what has already been said about the preliminary preparations, such as sorting

and scouring. We refer the reader to those aricles, which have received all due attention.

The spinning of carded wools is, without doubt, the most economical process for treating the inferior kinds of wool, mostly those qualities used for manufacturing common fabrics, such as blankets, coarse tapestry, petticoats, &c.

This kind of spinning is also superior to all others for fulled fabrics; and it is precisely the reason why cloths are manufactured from carded yarns. But for clothing, the finest wools are required, especially for articles of fashion and calendered cloths. For yarns of high numbers and soft and supple clothings we employ the wools from Australia, Silesia, and Champagne. Coarser clothings are made of coarse Spanish wools, and of the waste from the qualities above mentioned; this explains the cheapness of Spanish cloths which, however, are inferior to our own products.

The South of France produces a great quantity of common cloths. In the north the qualities are finer, and we may mention the products manufactured at Sédan, Elbeuf, Abbeville, and Louviers.

The common fabrics, such as blankets, &c., are manufactured, we have said, with carded yarns having themselves been made of all the waste produced in spinning combed and carded wools. These materials are numerous, and may be classified according to their quality and the uses to which they will be applied. They are:—

1st quality, barbs (from combed wool).
2d " soft twistings (from twisted yarns).
3d " end twistings (from the spinning process).
4th " flyings (from cards).

5th quality picked wool (from old knittings).
6th " breech locks (from the thighs).

Scouring.

The first condition in the spinning of carded wool is to have the material clean enough so that it will not absorb too much oil; and on this account the wool is scoured.

The greasy waste from combed wools is scoured the same as wool. The old oil which has thickened would be troublesome in the drawing process.

The flyings and breech-locks must be scoured also. For all that appertains to this manipulation, we refer the reader to the article on scouring.

End Twistings.

The end twistings, from spinning mills where combed wools are treated, are generally very much twisted, and therefore greatly resist the action of the picker.

We must then divide them, in order to diminish their resistance and render them more supple for the untwisting process.

For this purpose, we spread the end twistings over the table of a cutting machine. This apparatus consists of a rectangular cast-iron frame, which supports a spreading table, and various gears communicating motion to a shaft supplied with four steel blades. These blades revolving in front of the feed rollers cut the twisted yarns at any given length, by means of change pinions which impart various velocities to the feed rollers.

Rag Picker.

For several years past, old rags, knittings, &c., have been torn asunder, in order to convert them into common yarns.

The picking machine in use for this purpose has a wöoden frame similar to that of a willow. There is also a spreading table (endless cloth), but the feed rollers are covered with India rubbers. By this means the rags will not be so apt to rend. The drum is covered with steel hooks and revolves with great velocity. Behind the drum there is a circular brush which pulls out the filaments. The material produced (shoddy, mungo) is not much esteemed, as the filaments are too short and produce much waste.

Beating.

The beating process, in this case, is not the same as that used for combed wools.

The beater is made of an iron grating forming a large cylinder inclined about 8 or 10 degrees. In the centre and through the whole length passes an iron shaft, supplied with iron rods which assume the shape of a helix, and by this means the wool advances at each revolution of the shaft. At the upper part of the apparatus we have two pulleys, one of which is loose; and near them an endless apron which serves to supply the beater. When motion is given, the wool passes between the feed rollers, is carried off by the rods, and becomes opened. The dust and other impurities fall through the grating, and the beaten wool escapes through the lower opening.

The wools which are beaten in this kind of apparatus are, most of them, waste and short staple, because long wools are beaten by the ordinary process.

When wools of various colors and qualities are to be mixed, this should be done before beating.

Cleaning.

The cleaning is done, as we have said, upon the burring machine. Such wools, soiled with burrs, straw, &c., and particularly those from Buenos Ayres, Algeria, Morocco, and Asia, will have to undergo this operation.

Oiling.

All wools, whether mixed or not, are oiled before the carding process.

This operation, which is of great importance for carding and spinning, is done in the same manner as we have described in the case of combed wools, but the "Composition" is somewhat different.

For this composition we employ:—

1 hectolitre (100 litres) of hot water, into which we dissolve 15 kilogrammes of soft Picardy soap. Then we add, while stirring, 50 litres of oleine, and 50 litres of rape-seed or poppy-seed oil.

Table showing the Quantity of "Composition" to be used for a certain Quantity and Quality of Wool.

Number of the yarn.	Weight of wool.	Quantity of composition.
100	100 kilog.	24 litres.
90	100	23
80	100	22
70	100	21
60	100	20
50	100	19
40	100	18
30	100	17
20	100	16
10	100	15

The oiling is performed in the same machine (Fig. 23, Pl. VI.,) used for oiling wools which are to be combed. For details, we refer the reader to the article on oiling.

Picker.

The picker has already been described in the manufacture of combed wool; but in this case the instrument is smaller, the teeth finer, and the drum makes 800 revolutions per minute. Its diameter is 0.$^{m.}$80, the teeth included. The wool is rapidly projected out of the picker, which may be provided at the outlet with a large funnel, similar to those in use for cotton-beating machines; by this means, the wool is kept in an inclosed space.

In order to properly operate with this instrument, it is essential that the feed rollers should revolve easily, and that the charge of wool should be evenly spread over the apron. The wool, thus spread by the picker, is put into baskets and carried to the cards.

CHAPTER II.

CARDING.

FIRST PASSAGE.

The breaker used for the wool coming from the picker is similar in construction to that employed for producing the combed wools. Mr. Mercier, of Louviers, has a specialty in the construction of these machines.

Generally, the spools receive the roping at the base of the card and in front of it; but, whatever is the system employed for spools, whether near the floor or above, the roping produced is the same; consequently, either system may be employed *ad libitum.*

The reader will find all the necessary indications in the chapter on carding, for it is useless to repeat here what has already been said.

The spools obtained by this machine are irregular in weight, on account of the irregularity in the feed. All these spools are submitted to the next carding process, by which untwisted roving is produced.

SECOND PASSAGE. (CONDENSING.)

The second breaker is built in such a way that the wool, when leaving, is divided into several continuous rovings.

In order to regulate the working, 20 to 36 spools are put upon the creel, behind the breaker. I will state,

however, that it is more advantageous to adopt at once a constant number, say 36; for, if we are led to suppose that the spools furnish too much wool, we may slacken the feed rollers by changing pinions, and this is principally done when the cards carry too much and work heavily. When the cards are not overloaded, and in order to make a finer roving, we may act in another way, that is, by increasing the velocity of the doffer, which produces a finer roving. However, we should not carry these means of operating too far.

If great progress has been made in the manufacture of worsteds, that of carded wools is not behind it; for, during the last twenty years, the spinning of carded wools has attained surprising results, principally since the invention of the condensing breaker.

Any set of cards may be supplied with the apparatus necessary for producing a continuous roving; but when a spinning-mill is established in view of selling all the yarn, it is always more advantageous to buy new machinery.

The breakers built by Mr. Mercier are very much esteemed, and perform their duty perfectly well.

With an inferior breaker it is not easy to produce a continuous roving which is entirely regular; whereas by using one apparatus properly fitted, the products are always finer. Bad work, however, may be done with good cards; but it is due to the neglect of the operatives, and to the card clothing being kept in poor working order. This, unhappily, occurs too often.

The creel carries 36 spools. It is readily understood that the reunion of 3 spools will sensibly diminish the irregularities produced during the first passage. The

roping becomes engaged in a large comb standing in front of the feed rollers, passes under these rollers, and is taken up by the cards. The main cylinder, as usual, delivers the wool to the doffer, which is not provided with the same card clothing. Generally, these breakers are provided with two doffers; some have only one. The two systems produce a continuous roving, without any difference. The doffer is divided for 20 or 25 rovings, and in front of it there is a double plate bolster, which receives as many counter twist tubes as there are divisions upon the doffer. These tubes have great velocity imparted to them, in order to roll the wool coming from the doffer. The motion is imparted by means of a belt or a stout spindle band, which passes around each tube and acts by friction alone. The belt or band is driven by a pulley fixed to a shaft, which itself receives its motion from wheel gear attached to the shaft of the main cylinder.

When out of the funnel or tube, the continuous roving is strong enough to wind, without breaking, around a spool placed in front of the apparatus. Each spool receives as many rovings as there are tubes, and has a traverse motion, in order regularly to wind on the material.

The roving of carded wool is similar in importance to the sliver from the last drawing frame in the combing process. Therefore, it is at this period of the working, and at this machine that operators should give their attention, in order to ascertain the causes of unsuccess which sometimes occur.

The roving thus wound off on the spool, is carried to the spinning frames. The foreman samples (proves) the

roving now and then, in order to remain within the limits of the desired number. Many manufacturers, and we may say the majority of them, spin with numbers which do not correspond to the metric system; it is a nuisance, because it is much more easy to calculate with this system than with the antiquated one.

CHAPTER III.

SPINNING.

The spinning mule employed for carded wool is somewhat different from the mule used for combed products (worsteds). There is only one row of fluted rollers, provided with a quantity of small top rollers of iron. The carriage is nearly the same as in the case of combed wools, and the rack is provided with notches which receive the axles of the spools around which the rovings are wound off. Each extremity of the roving passes through a small funnel, and thence under the top rollers (not weighted), which prevent the roving from sliding off.

The whole machinery is so arranged, that the carriage may remain separated from the frame (roller beam) for a greater or less length of time, according to the amount of twist we desire to impart to the yarn. The driven pulleys, by means of an appropriate gear, communicate motion to the fluted rollers* and carriage. At a given time, the fluted rollers stop, while the carriage follows its course and draws out the yarn. The fluted rollers are stopped

* Very often these rollers are not fluted.

sooner or later, according to the draught we desire the yarn to undergo.

The main condition for producing a regular yarn upon these frames, is a great regularity in the motion of the spindles; they should, all of them, revolve with the same velocity, and the carriage must follow its track without any jerk, otherwise these irregularities would produce an irregular yarn.

When the operative puts up the carriage near the frame (roller beam), he should do it gently, and this is also another condition of regularity in the yarn.

Fine yarns are generally spun in two operations. Formerly, after the breakers, the wool was prepared into a coarse yarn without much twist; and this process, a few years ago, was followed for every kind of yarn, because there were no breakers making a continuous roving. But since this important invention, all the frames working coarse numbers have been transformed. There are several systems of condensing breakers for continuous roving; for fine numbers we employ the machine with tubes; but for the numbers from 1 to 12, we use that with rotary rubbers. Common wool is better treated upon the latter machine than upon the former, for the wool is always supported by the rotary rubbers and is wound off immediately after leaving them; whereas, by using the tubes, the distance between the tubes and the spool being considerable, the roving breaks, on account of the heaviness and want of cohesion of coarse wools.

Sampling and Numbering.

When a new batch of wool is to be worked upon a frame producing a known number, we follow this rule for changing the numbers:—

Multiply the known number by the pinion which has produced it, and divide the product by the number to be spun; the quotient will give the change pinion.

Example.—A frame is spinning No. 15 with a pinion of 50 teeth, and we wish to spin No. 20 with a new wool; what will be the pinion for producing this number?

$\frac{15 \times 50}{20} = 37.5$ teeth for the change pinion.

The draught for carded wools is never over 6 to 8, in two passages. Generally, the draught varies from 1 to 5.

For whatever yarn we require, the roving is prepared according to the number to be produced.

If, for instance, we desire to make a No. 10 yarn with a roving marking No. 5, and the draught of the latter being 4, what will then be its number?

The rule is: *Divide the number of the yarn by the draught, the quotient will give the number of the roving.*

Example: $\frac{10}{4} = 2.5$ number of the roving.

If we wish to know the draught necessary to convert a roving into a given number of yarn, then *divide the number of the yarn by the number of the roving, the quotient will give the draught.*

Example.—We desire to make No. 25 yarn, from a roving marking No. 12.5; what will be the draught?

$\frac{25}{12.5} = 2 =$ the draught.

If the run of the carriage is 2.50 metres, the roving will remain without draught for half of the run or 1.25 metre, while the remaining distance will be employed in reducing the former volume of the roving by doubling its length, plus the torsion (twist).

The number of the roving is equal to the number of the yarn, plus the draught.

No. 1 of yarn represents 500 metres weighing 500 grammes. The numbering of the roving is the same: 500 metres weighing 500 grammes make No. 1. But it is well understood that the sample has only a length of 25 metres, in order to avoid waste.

The doubling of the yarns is effected upon the doubling mule, or upon a throstle frame.

Throstle Frame.

The continuous system of spinning is one of the great applications of mechanics to the treatment of carded wool. For many years this problem seemed very difficult to solve; the difficulties were so numerous that the constructors who tried to build frames on this principle were not rewarded with success. It was reserved to Mr. Augustin Vimont, of Vire, to transform the intermittent (mule) into a continuous frame (throstle). Indeed, the frame constructed by Mr. Vimont is entirely different from the mule.

The industry of carded wool was the only one without its throstle frame; we owe therefore this great progress to this skilful constructor. The frame in its transverse section, looks like the throstle frame used for combed wools; its length varies between 7 and 7.50 metres,

according to the quality of wool under treatment; its width is 1.50 metres, and it is provided with 60 spindles on each side.

A large cylinder, revolving around its axles and bearing the roving, is at the summit of the frame. The roving in its descent becomes engaged between two rollers kept at a proper distance from each other, and surmounted with top rollers. It is well understood that the velocity of the top rollers is in exact ratio to the kind of yarn we desire to obtain.

The drawn out roving passes through a fly terminated by a tube, and becomes wound off and twisted by the rotation of this spindle. Each spindle receives its motion from a drum placed underneath the frame.

We readily see that the mode of operation of this frame is quite different from that of the mule.

For regulating the spinning, we employ the ordinary formula, that is to say, that whatever number of yarn we desire to produce, we *multiply the number actually spun by the pinion which makes it, and divide the product by the number to be spun; the quotient gives the change pinion.*

Example.—We desire to make No. 20, and know that the frame is spinning No. 15 with a pinion of 35 teeth; what will be the change pinion?

$$\frac{35 \times 15}{20} = 26.25 \text{ teeth for the change pinion.}$$

The draught for this kind of frame is never over 6 for fine preparations; but generally, another frame of the same inventor is employed, which is called *surboudineuse* (a kind of speeder), and is similar to the former, except that the roving is not twisted. Instead of spindles, there

is a movable roller which has both a circular and a slight traverse motion ; by this means, the drawn-out products are wound off around drums or rollers similar to the preceding ones. We understand therefore that the wool is unrolled, drawn out, rolled and wound off around drums which are carried to the spinning frame. This machine has the advantage of producing a more regular yarn than that obtained from twisted preparations.

The products of the new frame are excellent; the yarn is very regular, and the quantity produced amounts to 3612 metres per spindle in a day of twelve hours; then for 120 spindles we shall have:—

$3612 \times 120 = 433{,}440$ metres per day.

Now, if we desire to know the weight of the yarn spun during this lapse of time, we *divide the number of metres by the unit used for numbering, and multiply this quotient by the weight of the number we wish to know; the product is the weight wanted.*

$\frac{433{,}440}{500} = 866.88$ unit of numbering, and we desire to know, for instance, what will be the weight of No. 20.

Whereas No. 20 weighs 25 grammes, we shall have:—

$866.88 \times 25 = 21$ kilo. 672 grammes.

This weight leaves a profit, because the cost of spinning amounts to the wages of

2 women at the "surboudineuse."
2 " " spinning frame.

The *Conservatoire des Arts et Métiers*, on the proposal of its celebrated professor on spinning, Mr. Alcan, has just bought one of Mr. Vimont's frames.

Lighting the Spinning Mill.

At the present time, nearly all the spinning mills use gas-light, notwithstanding many new liquids vaunted by their inventors as being more economical and advantageous than gas-light. Whatever are those liquids, they will never be worth the gas obtained from the distillation of pit coal, in regard both to brilliancy of light and economy.

The manufacturers of carded and combed wools, being under the necessity of scouring their material, produce a large quantity of soapsuds, from which little profit is generally obtained.

These soapsuds, as I have said in a special article, may be transformed into a solid material very good for the manufacture of illuminating gas. The apparatus necessary for producing this gas is not very expensive, and not only soapsuds, but all kinds of greasy residue from spinning mills are convenient for this purpose.

In one word, all such waste of manufacture will generate gas, and the products of the condensation will be found useful in agriculture, as manures.

The gas obtained from the distillation of pit coal is a mixture of hydrocarbons, which are without color and with but little odor, when properly purified. Its specific gravity is 0.555, and it is insoluble in water.

Pit coals often differ according to the locality from which they have been extracted; it is therefore very important to know which qualities are the best. Some kinds of pit coal will give double or triple the quantity of gas of others. As it is very difficult to determine

by sight alone such differences, the best, in this case, is to make a trial.

Mr. Regnault has divided pit coals into five classes, in his remarkable work on mineral fuels. In gas-works, we consider only two species: bituminous and semi-bituminous coals.

Bituminous coal (caking coal), or forge coal, is black and easy to inflame; by burning it becomes soft, pasty, and swollen, and the flame is white with production of smoke. This kind of coal produces much gas and a voluminous coke. Certain English coals, called cannel coals, are very much esteemed for making gas. Semi-bituminous coal (cherry coal) is hard, compact, and not so black as the highly bituminous kind; its flame is bluish, and the coke produced is not so easy to enflame.

The Flénu coals (Belgium) are considered very advantageous for making gas.

There is a great profit in using dry coals; those which are wet give inferior products.

At the present time, we employ clay retorts, and a cherry-red heat is the best temperature for producing the most illuminating gas; if this temperature is exceeded, the retorts and the furnaces will soon be destroyed, and the consumption of fuel will be increased.

The gas-holders should be greater than what is actually needed, in the event of future exigencies.

With a proper heating, one hectolitre of pit coal (80 to 85 kilogrammes) produces from 25 to 30 cubic metres (26 on an average) of gas of good quality, 131 litres of coke, 6.420 litres of ammoniacal liquors, 6.250 litres of thick coal tar, and 0.045 litre of volatile hydrocarbons.

The consumption in fuel ought not to exceed 50 to 55 litres of coke, or 23 litres of cherry coal.

In order to estimate the cost of the gas necessary for lighting a spinning-mill such as we have examined in this work, we shall suppose that we require gas-light two hours and a half every day, during six months of the year, and that the burners are distributed as follows:—

Sorting-room	2	burners.
Office	2	"
Cleaning and beating-room	4	"
Steam-engine	2	"
Scouring-room	5	"
Drying-room	1	"
Carding and combing	15	"
Preparations	8	"
Spinning	30	"
For various purposes	6	"
Total	75	burners.

The consumption of a burner (bat's wing), such as is generally used in spinning mills, is 130 litres of gas per hour.

This consumption is exceeded when no regulators are used. Every one knows that, when part of the burners are extinguished, the remaining ones will burn with such an intensity that their consumption will be doubled. With the regulator we obviate this grave defect.

Knowing that we have to supply gas to 75 burners during two hours and a half, and that each burner consumes 130 litres of it per hour, we shall have: 130×2.5

$=325$ litres per burner and per day, or $325 \times 75 = 24,375$ litres (or 24.375 cubic metres) per day and for 75 burners.

We have already said that a hectolitre of good coal will produce 26 cubic metres of gas, therefore 24 cubic metres will require less; we will however admit one hectolitre.

The cost will be:—

1 hectolitre of bituminous coal (80 kilogrammes).

1 day's work to attend to the furnace.

50 to 60 kilogrammes of coke or pit coal.

Other expenses (repairs, interest, &c.).

We must notice that when a large quantity of gas is to be distilled in a large furnace, the consumption of fuel is not over 30 kilogrammes for each hectolitre distilled.

When there is no advantage in selling the coke, it is employed as fuel under the retort.

From the above cost we have to deduct the value of the coke sold or not consumed, of the tar, and sometimes of the ammoniacal liquors.

By applying figures to these data, it will be seen that the gas bought from a company is generally more expensive; whereas by making it ourselves, it will be superior in quality and constant in price.

APPENDIX.

WOOLLEN MACHINERY AND MANUFACTURES AS SHOWN IN THE UNIVERSAL EXPOSITION, PARIS, 1867.

EXTRACTS FROM THE REPORTS OF THE INTERNATIONAL JURY.*

From MM. Michel Alcan and Ed. Simon's Report.
Vol. IX., page 182.

§ 1. Processes for Cleansing Wool.

It is not our object to study here the chemical processes for washing and scouring wool. Many learned persons have already and fully considered that subject, and special reporters will certainly indicate its standing at the Exposition; but it belongs to us to point out the most general substitution of automatic processes for those which required manual labor, or the action of the feet in the washing of wool. The apparatus for scouring combing wools differ from those for carding wools, only in a few points. Smooth and straight filaments will bear, after the operation, a strong pressure, in order to expel the water they hold; on the other hand, short and wiry wools, employed for the manufacture of felted goods, ought to remain open as much as possible. The various exhibited systems are in practical use, and work daily large quantities of material. All tend to wash and scour at the same time and in a methodic manner, with the least labor; and they have all resolved the problem to such an extent that it is difficult to come to an ulti-

* "Rapports du Jury International, publiés sous la direction de M. Michel Chevalier, Membre de la Commission Impériale." 13 vols. 8vo. Paris, 1868.

mate decision about the relative merit of the apparatus exhibited by the machinists of Reims, Verviers, and Rouen. For that it would have been necessary to devote to comparative experiments more time than the Jury had to spare, in order to arrive at results based upon the quality of the wool under treatment, the cost of labor variable with the localities, the amount of water necessary, &c. At all events, whatever is the system in use, the new processes offer the advantage of an easy and perfect cleansing, at a lessened cost, and sparing the men unhealthy labor. A certain set of these machines, requiring only the attendance of three men, and eight horse power, scours, rinses, and dries in one day from 10,000 to 12,000 kilogrammes of wool (10 to 12 tons). The increasing employment of such machinery has caused the cost of scouring to fall successively from fr. 20 to 12, and down to 5 per 100 kilogrammes of scoured wool, taking into consideration the soap, the labor, and the motive power. We regret that we have not room enough to describe the ingenious machines which give such help to the industry; we can but refer to the special works recently published.

The automatic scouring is actually followed by the processes of dyeing adopted by Mr. Gouchon, a manufacturer of Normandy. This inventor obviates the slowness, irregularity, and comparatively high expenses of the manipulations of dyeing, by means of rational apparatus, arranged according to the nature of the material under treatment, and preserving the character of the fibres, which, too often, are impaired by the usual process to such an extent as to make the spinning very difficult. We mention these new processes, which did not figure at the Exposition, because we think that they are destined to realize, in the mechanical part of the work, an improvement worthy of the chemical progress in dyeing.

§ 2. Combed Wool.

The industry of combed wool, from merino and long wool, is represented at the Exposition especially by the first and the

last machine of the assortment, that is to say, by the combing machine and the mule. In these apparatuses only can we see modifications worthy of remark. We shall not repeat here what we have said in the article on cotton, relatively to the successful endeavors for replacing the mule by the throstle frame, and to the improvements in self-acting mules. The combing machines, which are completely represented in the French Section, are remarkable for the perfection of their construction, and the precision of their working.

Derived from the principle of Heilmann, some combing machines have been entirely modified, as well in the general disposition and the volume of the organs, as in the transmission of motion; the others have received some partial improvements, which have increased the amount of work performed without impairing its quality. The machine which most differs from the primitive type by its construction and its products, is that exhibited by Mr. Mercier, under the name of its inventor, Mr. Noble. This apparatus may have some defects accruing directly from its qualities, and the great number of spools put around its circular frame produces a somewhat confused appearance, and necessitates an amount of care resulting from an accumulation of organs. On the other hand, the Prouvost combing machine, of English origin, is remarkable for the simplicity and the economical arrangement of its different parts. The Morel machine, like the preceding, is intended to work common wools, and presents valuable improvement on the feeding part of the Heilmann system. Moreover, its whole transmission is comprised in a metallic drum, which is cast with the eccentric guides of its inner surface, the machine is more open, satisfactory to the eye, and its working is easy. MM. Schlumberger continue to perfect the apparatus bearing their name, and which has been so successful. The firm of Stehelin & Co. exhibits a Lister combing machine, with a valuable modification for making less noils. This great variety of similar machines allows each manufacturer to choose the apparatus best adapted to each sort

of wool, and explains the success of this French specialty, which goes on continually improving.

§ 3. Carded Wool.

Here again the most noteworthy improvements are to be found in the first and last operations of the manufacture, and show that questions, secondary in appearance, and too much neglected, are being studied. For instance, the oiling, which, in this manufacture precedes the carding process, was left to the care of a workman, who sprinkled the filamentous material with more or less regularity, before it went to the breakers. Various automatic apparatuses have supplied this want. Accurately constructed, they not only lubricate the fibres equally, whatever is the quantity of oil or of emulsion in the tank of the apparatus, but they also provide for graduating the proportion of the oiling material according to the nature of the wool.

The feeding of the cards (breakers) has also become entirely automatic; and in presence of the constantly increasing cost of labor, the wool manufacture has found a powerful auxiliary in the "automatic feeder," which, under different forms, was exhibited in the Belgian and French sections. This apparatus, as is the case in most similar improvements, works with more regularity, and saves much labor to the workwoman, who, until now, was obliged to stand all the day long with her body stretched forward, in order to spread on the feed-table the wool divided by the hands.

A want is felt of intermediary machines for insuring regularity in the doubling; there are difficulties which the builders are trying to overcome. The Apperley system consists in presenting obliquely to the second breaker the irregular roping of the first card, and then, by a similar disposition, feeding the finishing or condensing card. The continuous naps or laps of Ferrabee, disposed upon endless cloths, and whose crossway motion produces a true doubling, are instances of experiments

in this direction. Already these processes have been put into practical use, but there is room for improvement.

The breakers, whose cylinders, according to the country, are made of cast-iron, wood, stucco, pasteboard, or saw-dust, have had their finishing organs improved the same as the feeding ones. The doffer of the last breaker (condenser), where are made the rovings which will be drawn out and twisted on the spinning frame or mule, required a delicate mounting of annular card fillets, in equal number to that of the rovings produced. An ingenious disposition, invented by Mr. C. Martin, of Pepinster, Belgium, allows the clothing of the doffer to be made of a continuous fillet, the same as with the other rollers; the divisions are marked and kept by steel springs, which slightly touch the extremities of the card teeth. We have not been able to ascertain the result of this disposition with wools of various lengths, but what was to be seen at the Exposition already indicated progress.

The self-acting mule, which for a long period was used in cotton mills only, is at the present time adopted in nearly all the great woollen manufacturing centres; and the great number of these machines, working quite well at the Exposition, notwithstanding the unfavorable conditions they are subjected to, is the best answer to the objections made. We have already stated the improvements which have caused this success; and we have also mentioned how important we consider the employment of throstles, among which the Vimont frame is the type for carded wool.

The economy accruing from automatic apparatus may be set down at from 30 to 45 per cent. in the manufacture of yarn, at the same time that the salaries have been increased from fr. 0.50 to 1.00 per day.

Small pieces of machinery.—They do not constitute, in every country, a special branch of manufacture. Generally, the large English houses manufacture for themselves these small pieces, such as spindles, flyers, fluted rollers, top rollers, steps, plate bolsters, &c. The French manufacture, on the other hand, obtains

these pieces from special workshops. The firm of C. Peugeot & Co., of Audincourt, well known by the progress it has effected in this speciality, and by the perfection of its working tools, employs five hundred men; an examination of its products is sufficient to explain a part of the progress shown by the spinning frames. The well-studied shape of the spindles which have to bear the increased velocity required of late years, the quality of the hardening and tempering, the reduction of 10 per cent. in the cost, all these result from tools perfected so much that children can produce with them a large portion of these delicate instruments. The combs, gills, porcupines, &c., employed in the machinery for flax and combed wool, although without much change, denote the great care given to their manufacture by several firms of Lille and Roubaix. This speciality in the manufacture of the small pieces is favorable to the perfection of the whole spinning apparatus, because the builder, being certain of the perfection of these separate pieces, gives all his attention to the construction of the frame and of the transmission.

Spiral springs stuffed with wool.—Among these separate pieces, we see in the Class 55, metallic spiral springs, the inside of which is filled with wool, strongly compressed. From authentic data, furnished the jury, it appears that these springs are advantageously used on several American railroads, and that practical experiments made in England, have also given satisfactory results. Before theory can explain how the combined elasticity of the wool and of the metallic spire can remain unimpaired under very great and protracted strains, the exhibitors, MM. Thompson & Co., have thought of manufacturing such springs of every size, to take the place of those whose working is irregular in spinning frames, looms, fulling and finishing apparatus, &c. We have mentioned this invention, on account of its originality, and of the services which are expected from it.

Card clothing.—The preceding considerations on special and separate pieces, may also be applied to card sheets and fillets, which form an important branch of manufacture. These products appear to be uniform, but the variety of types, as seen at

the Exposition, is a proof of the difficulty of their fabrication. Not only each filamentous material requires an especial size of tooth, but the clothing must also vary at each period of the operation for the same substance. Moreover, the fillets are made of leather, with and without stuffing, or of leather doubled with another sheet of India-rubber, which increases the elasticity of the metallic hook. All these sorts of card clothing are numerously represented, and show the union of skilled labor with well-regulated machinery. However, those of the highest standard are of one of our French manufacturers, Mr. Bourgeois Botz, of Reims, whose show presents a perfection and a regularity which cannot be excelled.

From M. Larsonnier's Report.
Vol. IV., page 131.

PRODUCTIONS EXHIBITED.

We shall now pass in review the different nationalities whose products contributed to the success of the Exposition of 1867.

England is the first to attract our attention by the perfection of the mixed fabrics exhibited by the cities of Bradford, Halifax, Leeds, and Norwich. The collective exposition of Bradford possesses most remarkable specimens of tissues of alpaca, goat's hair, and lustrous wools. Its superior qualities of Orleans, Cobourgs, and Paramatas are uppermost as mechanical productions. Before such a superiority Roubaix must be satisfied with the second rank, because it has not succeeded yet in spinning well the alpaca, goat's hair, or the mixtures, in which our neighbors excel; even with the English spun material, Roubaix is inferior to Bradford as regards the weaving. It is true that the Yorkshire manufacturers have been in possession of that industry for many years, while our attempts are only of a recent date, and it is therefore not astonishing that they have mastered it more thoroughly than we. We have also ascer-

tained that the fine qualities of Bradford's goods were not, in 1867, superior to those exhibited in 1851; that is to say, that at the first universal exposition, the fabrication had attained the last degree of perfection.

For an inferior class of goods, England, as well as France, has been obliged, before the universal demand for cheap goods, to lower the quality in proportion to the prices. In the absence of important inventions, which might have opened new outlets, the English manufacturers have devoted themselves, with their well-known aptitude and perseverance, to the improvement of their manipulations, of their looms, and especially of their dressings, which remain superior to ours.

To sum up, they are and appear that they will be for some time to come, in advance of Roubaix for plain goods, which require no taste or new combinations. However, we must recognize the fact, that in this respect they have progressed by our contact, and made profit of our lessons.

If it is true that Roubaix, late in the contest, has not been able to raise its mixed fabrics to the perfection of those of Bradford; it is also certain that the English manufacturers have vainly endeavored to compete with France in the fabrics of pure wool. Their repeated attempts have been unsuccessful, whether for articles requiring a complicated mounting and not adapted to the power looms, or for those easily made products, such as mousseline de laines and merinos. This is not to be wondered at; France had already carried so far the perfection and the low price of all wool fabrics a long time before Australia had supplied England with merino wool equal to ours; the profits of our manufacturers were so much reduced, even before 1862, that our intelligent neighbors have rapidly ascertained the small results to be expected. They have wisely bought from us the tissues of pure wool, and have directed their efforts towards the mixed and cheap fabrics which are better adapted for the million, and are to be found in all the markets of the world. In 1862 an English manufacturer had exhibited various specimens of pure wool made after our models and quite successfully.

His intention was to implant in Scotland the weaving of tissues similar to those of Reims. We have vainly endeavored to find his products at the present Exposition, and we have learned that, not satisfied with the results, he had, in common with a few other manufacturers, given up the undertaking.

England has not been sufficiently well represented in the department of flannel and other carded and slightly fulled goods, for us to form an opinion. We regret the absence of the Rochdale manufacturers, because their specialty at London, in 1862, was remarkable for the extent and the quality of the product.

The progress of Prussia, Austria, and Saxony has been rapid from 1855 to 1862, and from thence to 1867 it is also plainly seen. The Germans have advanced at the same rate as England and France, but by different roads. Favored with very cheap labor, their tendency has not been towards the power loom, although their products are exceedingly cheap. We have remarked in the show of Prussia and Austria a certain number of articles tastefully made; however, with a few rare exceptions, their manufacturers do not incline towards original products. They mostly imitate those of France and England, which are found to be of ready sale. Studying carefully the principles, but lowering somewhat the intrinsic qualities of the models, they are enabled, by the cheapness of their products, whose appearance is similar to ours, to raise a severe competition in the foreign markets where most of their production is sent. Until now we have imported little from Germany. Our consumers still prefer goods superior in quality to those offered by the Germans; but these latter are skilful and enterprising, and bent more than ever towards progress, and it may be possible that their competition will prove to us more formidable than that of England.

Belgium is far from having remained stationary; its industrial organization has been greatly developed and favored of late years by powerful associations. The main point was to become enfranchised from English manufactures, and in that, Belgium has nearly succeeded. All her attention has been towards manu-

facturing very cheap goods for popular use, and her success has been such, that a portion of her products are exported, and enter into competion with those of Bradford, Manchester, and Roubaix. We have not found that her fabrics of pure wool could be compared with those of French manufacture; and as regards articles where taste and superior quality are the object in view, whether made of carded or combed wool, or of mixed material, we may conclude that Belgium is and will remain our tributary for some time to come.

Russia, already represented at the last Exposition of London by several distinguished manufacturers, gives the proof, in 1867, that she does not intend to remain behind the other nations. The manufacturers of Moscow, and of several other cities of the Empire, have submitted to the International Jury several very interesting products, which show a sensible progress. These are mostly copies of mixed fabrics from Bradford, and of pure wool goods from France. Certain sorts of merinos, of Scotch cashmere, and of Chinese satinet, have more particularly impressed the Jury, who were also very much interested by the data given by the Russian commissioners concerning the impulse given of late years to the large factories of Moscow. To become possessors, as soon as possible, of the market of their vast empire, under protective duties, is the national plan for which Russian industry, and especially that of Moscow, labors with great energy, at least for what concerns the articles comprised in Class 29.

We can say the same of Spain; her object is the same, and to obtain it the manufacturers of Catalonia lend all their efforts. If we look several years back, we see the owners of the large Spanish flocks sending nearly all their products to Bayonne and Rouen, to be taken from thence by the manufacturers of Elbeuf and Reims. But for five or six years past the importations of wool from Spain have been constantly decreasing, while the manufactures of Barcelona absorb the greater part of it. It is not a great loss for us, because we have advantageously replaced that wool by those of Australia and La Plata; but the

facts we are pointing out, combined with the increased duties put by the Spanish Government on all our tissues, prove the actual tendency. We cannot say that the fabrics exhibited by Spain show a great degree of perfection, but they rank in the general progress of the woollen industry, and are already a serious obstacle to the sale of French products in the Spanish market, the more so that the system followed by the manufacturers of that nation consists in a complete copy of successful articles, whose sale is immediately advantageous to the imitators.

We have little to say about Italy; her industry has not furnished any object of study for the Class 29 proper; but some specimens of carded wool, coming from manufactures already well established, gave us the proof that there also an industrial impulse has commenced.

We have vainly endeavored, in the section of the United States, to find specimens which would allow the Jury to form a sound conclusion as to the progress of this American industry. Was it the intention of the Massachusetts manufacturers to keep as a secret what is well known of those who, from near or far, observe the development of the colossus of the New World? From their go-ahead spirit, and their rapid progress, we are authorized to perceive that a day will come when the Americans will become serious adversaries of England first and France afterwards; and that America, in the name of free trade, will come among us to find consumers for her manufactured products. Will this be in ten or twenty years? But without investigating the future too profoundly, we certainly see the American products competing with those of Europe.

Considering our constantly increasing exportations, notwithstanding the unfavorable condition of business in 1867, we think unfounded the fears expressed by some honest minds, as follows: "The great nations having understood that England and France owe, in great part, their richness and preponderance to their industrial and commercial development, it is a legitimate ambition for Germany, Belgium, America, Russia, and

Spain to hasten in drawing at the same source their portion of riches and of power. The large field of production therefore goes on constantly increasing. Will not the consumption fall behind these rapid strides? Will new channels open to the manufactured products be sufficient to absorb them all; and is there not danger that the equilibrium between the supply and the demand will soon be broken, entailing a deep perturbation in the great industrial interests?"

These considerations are not without being echoed by the business world, who, at the present time, are deeply interested with the economical questions on which depend the material welfare of our country. Whatever are the answers to be made to these anticipated fears, France has nothing else to do but to follow with perseverance the direction in which her efforts have been successful. The future will prove that all the products of human labor find their place, and that consumption breeds consumption.*

* *Exportations of Woollen Goods.*

	1861.	1866.
From England to France	12,173,000	27,049,000
From France to England	10,776,000	37,549,000

The values are in francs.

MACHINERY FOR WORSTED FABRICS, ETC.*

By JOHN FRENCH,
BRADFORD.

(*Extract.*)

Class 55.—Belgium.

This was a complete set of machinery for the manufacture of cloth. There were the "cards," in the first place, which, I must confess, were very good, and appeared to do their work very well. There was nothing about them I had not seen before, and, consequently, I had nothing to learn here. There were also the "roving," "throstle," and "mules;" the "measuring," "dressing," and "folding," which, taken as a complete set, do credit to the exhibitor; and it may with safety be said that this from Belgium was indeed worthy of notice.

Manufacturing Machines in the French Department.

In looking over this department I examined some machinery made by Mercier, of Louviers. There were three carding engines; the first was "teaser and card." The material from this card is taken from the "doffer" by a funnel on one side, next to the other card, and it drops upon a receiving-belt, by which it is carried to the breast of card No. 2, and placed upon the feed-board, in a diagonal manner, by an upright drawing

* From "Reports of Artisans selected by the Committee appointed by the Council of the Society of Arts to visit the Paris Universal Exhibition, 1867." London, published for the Society for the Encouragement of Arts, Manufactures, and Commerce, by Bell & Daldy, 8vo. 1867.

traverse. After the process of carding, it is again drawn off the doffer by a funnel, and carried to card No. 3, in the same manner I have before described; and in this card it is subject to the condensing process, and in this state it is ready for the mule.

The processes here described may perhaps feed the machine more regularly, if the first be regularly fed, and perhaps might dispense with a few hands where a number of machines are at work, but it is very questionable whether the work would be so well done as when there is some one to attend to it in a proper manner. My own impression is confirmed by what I have seen elsewhere, that the gain would not be so great as some people might be inclined to imagine, and therefore I cannot approve, where I am convinced there is no practical advantage.

France—Classes 55 and 56.

This was a spinning frame, a peculiar kind of throstle. The flyer was suspended, and ran on two necks with a whorl between them, and it was driven by a cylinder. The spindle was on a separate rail, and driven by another cylinder. The spindle-rail traversed up, and the spindle had on it a paper-tube. It was spun in the cop-shape: and by a nicely adjusted speed of the flyer and spindle, which ran at different speeds, it was possible to spin a very fine thread, and as it was the only one in the Exhibition, and as I saw none like it in any of my travels, I set it down as one of the novelties of the present day.

I may here observe that the carriages by which the wool was drawn were similar in every respect to those which I made for Mr. Hargreaves, of Kirkstall-bridge, to apply to the mule, in the year 1845 or 1846.

It now became my duty to look over the English Department, and in doing so I was much gratified to find Englishmen, with whom I could converse more freely.

I was glad to find that one of our Lancashire firms had a complete set of machinery for cotton, from the "scutching machine" to the "mule" which spins the thread.

This machinery is worth the time spent in its examination; and, I must say, great credit is due to them for the pains which they have taken to show their machinery, which is of the highest class, and second to none in the Exhibition; and I think that they themselves must derive satisfaction from the great interest taken in it when working, by the crowds of spectators who throng around them, to see the whole of their machinery in motion.

The next machinery I noticed were the Lancashire looms, made by Cook and Hacking, as well as those made by Smith, Brothers, of Heywood, both of which are very good. The price of the plain loom made by Cook and Hacking was £7; the Jacquard loom was £15. The loom made by Smith, Brothers, was intended for the weaving of cloth, and had very peculiar motions about it, one of which was the slay-board; it is motionless while the shuttle is being picked across. The looms, altogether, do credit to the exhibitors.

The next that came under my observation were the looms from Keighley and Bradford. With respect to these looms, I think it is impossible to find any within the precincts of the Exhibition, or elsewhere, to compare with them; and had it so happened that I had been a native of any other place than one of these towns of whose productions I am speaking, I might have particularized, and spoken more freely, upon their respective merits; but in consequence of being acquainted with, and enjoying, as I trust I do, the personal friendship of every exhibitor, I do sincerely hope that they will excuse my declining to express an opinion, which might be considered to be in favor of one more than another; therefore, I can do no more than say of them, as a whole, that they have maintained the position that Yorkshire has held so long, and one which, I trust, she will hold for a lengthened period to come.

The next machine to which I directed my attention was one patented by Augustin Vimont. This machine was somewhat similar in principle to one I had seen tried by Mr. Joseph Greenhough, when he occupied a portion of Marshall's mill at

Bradford, a great number of years ago. It is introduced at present to supersede the mule. There is a ring fixed upon the lifter, round which the thread from the roller passes from thence to the spindle, which can be set to any height, to suit the material which is being spun. The lifter is the traverse, which distributes weft on the spindle. The spindle is driven by a cylinder, and runs with great velocity. The carriage in which the draught is effected is very peculiar, having two fans, working in contrary directions, at a good speed, between the back and front rollers, to equalize the thread. The proprietor states that he can produce as much again as on the mule, which statement I am not disposed to credit, inasmuch as, from what I saw while the machine was working, he could obtain no such results.

Machinery from Roubaix.

There is one spinning frame in the Exhibition, which has been made at Roubaix, on a rather less scale than those which are made at Bradford.

I was very glad when I saw there was a frame of the Roubaix make, but was sorry indeed to find that it was not in working order, and, consequently, could form no judgment of its capabilities as a machine. I subsequently discovered, when in another part of the country, that this identical frame had been tried, but would not answer the purpose, and was afterwards placed in the Exhibition, but with what intention I cannot say.

Finding things in this state, our next inquiry was, "Has France the machinery here with which she makes the yarns and pieces which we see in this Exhibition, or is it in another place, with an impassable barrier between us?" The answer was given by a Frenchman, "It is not here. I am myself connected with manufacturers, and it would not answer our purpose to show them in this place."

The next step to be taken at this time was one surrounded with anxiety and doubt. To gain admittance to their places of manufacture was no small matter to contemplate; but it must

be done, or we should have had to return home without that very information which it was our sole object to obtain.

In anticipating such a result, we had requested M. Haussoullier to be good enough to write to several firms in different parts of the country. I believe he wrote about twenty-one letters, a few of which were answered favorably, and comprised among them some of the largest establishments in France.

Our Visit to Reims.

Upon entering the manufactory of M. Dauphinot, we were first admitted into the office; and the first thing that arrested my attention was an article which had been made to test the strength of yarns intended for weaving. It was a beautifully-made instrument, so arranged that a weight could be suspended to the yarn, and should it bear it for the space of five seconds, it was considered strong enough to be woven in a loom driven by power, but should it break in the experiment, the material was thickened a little, not twisted harder, to enable it to bear the weight the required time, and the process was concluded. The instrument was neatly made, and very simple in its construction.

We then proceeded to inspect the raw material, which had to be subjected to the various processes, among the machinery, and found it to consist of French, Prussian, and Australian wools, by far the greatest bulk being Australian.

We were then introduced into the department where the machinery was, and the first that attracted our attention was the "washing rollers." We found them to consist of three pairs, through which the wool had to pass before it was considered thoroughly washed; and from the last pair it was thrown into a skep by a quickly-speeded fan, to be taken from thence to the dry-room.

The drying-machine was a steam-box, about 6 yards long and 3 feet 6 inches wide. The wool was conducted through a heated chamber, on an endless chain, underneath which were three fans, revolving at a quick speed, to agitate the rarefied air,

and to assist in drying the wool, which was ultimately discharged at the other end of the machine into a box placed there for that purpose.

It was taken from this machine to go through the oiling process, it being considered by this firm that some sorts of wool require a little oil in the early processes through which they have to go. The application of the oil is strictly confined to one man, appointed for the purpose, who is very careful in distributing it equally over the various layers of wool to which the oil has to be applied.

The process of oiling being concluded, it is then taken to a double-cylinder carding-machine, and with the greatest care arranged on the feed-board, with the ends of the fibres pointing in a proper direction towards the cards, and it is delivered from the doffer of this machine on to a balling-head, and this concludes the carding process. It is then taken to the back washing-machine, and instead of a great number of them going through in a bulk, each ball goes through singly, and consequently is thoroughly washed and dried in its passage, to be again formed into a ball. It is then taken from the back washing-machine to the combs, some of which are almost similar to those of Mr. Rawson, but I believe they are made in France. I must here state that the preference is given to Schlumberger and Co.'s—a small machine, adapted for fine wool, and although they do not comb a great amount per day, the deficiency is made up by having a great number of them.

The next process is that of "drawing," and this is a very important one. The first machine is neither more nor less than a balling-head. The back roller, which in this machine consists of two sets, is about two inches in diameter, and revolves on movable stands, so that it is easy to vary the length of the ratch when it is necessary, but that is not often the case. It then passes from the back roller, sometimes over a carrier, but frequently without one, then over a porcupine, which is placed close to the front roller. This roller is about two inches in

diameter, the porcupine about the same. It then passes forward to a balling-head, and the first process of drawing is completed.

The next process is about similar to the last; but as the material proceeds in its course, the diameters of the back and front rollers, together with the porcupine, gradually diminish, until at last, when it comes to the "roving," the diameter of the back roller is about an inch, the front roller the same, and the porcupine even less than that. In this process, when it has passed the front roller, and proceeds in its course to be formed into a ball, it is delivered in two distinct rovings, and separately rolled together by vibrating leathers. It then passes through a guide on to the balling-head, apparently one roving, but in reality two, and in this state it is taken to the mule, after having gone through, according to the workmen's statement, twenty processes to bring it to this state of perfection; and during the whole of these processes it has never undergone one single twist per inch.*

The mules of this establishment consist of about 600 spindles, each with a carriage similar to those which I have previously alluded to, and which I made for the purpose of drawing Indiana wool. They have back rollers, two rows of carriers, and a front roller, all of small dimensions. The top carriers are made of iron, about three-quarters of an inch in diameter, which I found in this establishment to be of great utility, from the fact that our guide took them off to show us how twitty the yarn was without them. The "top-pressing," back and front, are both weighted with one lever, having a small weight attached to the end thereof. It may be here remarked that the mules, as they are wrought here, are upon a somewhat different system to that

* The drawing is entirely without twist in the last two or three operations, in which the slubbing becomes small. It passes between cloths, each cloth stretched by two rollers, which receive and carry it forward, the rollers at the same time working transversely; in this way rubbing or rolling it together, imparting firmness sufficient for it to be drawn off at the next machine.—"*Report of Artisans.*" *Report of George Spencer, of Bradford, on "Worsted Yarns," etc.*, p. 399.

worked in our own neighborhood. With us a certain amount of material is let in, and the spindle-carriage draws it out to its full length; but with those in this establishment, the front rollers continue to draw the wool till the spindle-carriage has got to its extreme distance.

We next proceeded to the "weaving department." Here I find a little difference in the looms from those made at Bradford. The alterations they have made I do not approve; for instance, they have a casting bolted to the upright picking-shaft, instead of a stud and cone, which I consider much easier for picking, in consequence of the cone revolving. They have also another plan, somewhat different to our own, which is, instead of working the treadles from the end of the tappet-shaft, they work them from a cross-shaft, geared with bevel wheels to the low shaft, and the treadles work in the centre of the loom underneath. I do not know the reason why they have adopted this plan, as I cannot see any benefit to be derived from it.

There is one remark to be made here, which is, that the pieces have to pass through two rooms, in each of which are kept a number of work people; in the one, all the pieces are examined to detect flaws if there be any, and to mark the same; and in the other room those defects are remedied, so that it is scarcely possible for the human eye to find where the imperfections have been.

The next process to which the piece is subjected is one which I think worthy of notice, and the machine through which the piece has to go is the first I have ever seen for the same purpurpose, that of dressing worsted pieces; for the sake of illustration, I will compare it to a loom having two slay-boards placed in it.

On each edge of the wood-work is fixed a plate, with square edges, projecting a little above the top, and between these plates are adjusted knives, with a peculiar edge, for the purpose of dressing the piece. There are also rollers in the machine, some of which are stationary, over which the piece is drawn, in order

to stretch it very tight, and a beam on one side on which to roll the piece.

The machine is then set in motion, and an astonishing process commences, by the piece being drawn and tighly stretched over the four square-edged plates, placed upon what I have termed the slay-board, so adjusted as to prevent the knives from injuring the piece; and by moving backwards and forwards at a rapid rate, it is truly astonishing what a fine appearance the material presents after being submitted to this process of dressing. After having gone through this machine, it is then ready for the process of dyeing.

The number of horse-power at this establishment is about 220; the number of hands employed is about 800; the mules contain about 900 spindles each, and five persons superintend two of them, or about 1800 spindles. This firm has altogether about 20,000 spindles. They use Schlumberger's combs, and have about forty of them.

We visited another establishment, where there was weaving only, the whole of the looms being of Mr. George Hodgson's make. The regularity and order kept in this establishment were very good. In the machinery I have nothing particular to remark.

Our next visit was to Mr. Holden's large combing establishment, but our stay here was of short duration, in consequence of our having to start for Paris in about an hour's time, or extend the period of our visit to the next day. We however decided that, as there were only carding and combing processes going on, we would take a sharp survey of the interior of this vast magazine of industry, wherein were working 160 carding engines and 100 combing machines, which are all fully engaged night and day. Here are kept a great number of mechanics, who make their own machinery, as well as repair it. The combs are of their own invention, and I believe they are patented. They are in some respects similar to what I have seen before, with the exception of the filling part, which is accomplished by two

eccentric motions, which, according to my opinion, do not work so neatly as the nip which is applied to Mr. Lister's combs.

Our next visit was to Henri Delattre, Sen., and Co., at Roubaix. This is the Bradford of France. Here, for the first time in all my travels in France, I find machinery which has been made in England for the purpose of preparing and spinning. This machinery was made by William Smith and Sons, Keighley. The preparing is in every respect similar to our own, and the spinning has been made especially for "mottled yarns," with two rows of bottom-back rollers, the "top pressing" working between them. I found their newest frames had larger bosses on the front roller than usual, they being five inches in diameter—an alteration of which I do not approve. The spinning-frames contain about 148 spindles. The place is conducted in very much the same manner as our own are. I observed, however, one little difference—which was, that two young men were continually walking from one end of the room to the other, and their sole duty was to see that no bad piecings, or sullied yarns, or any other imperfection, were allowed to pass on to the bobbin. While I passed through the room I saw them call the attention of more than one spinner to what they considered imperfect yarn; so that here we see the same great care is manifested which characterizes all the manufactories which we have visited in France.

In the other room we find that the preparing is adapted for the finer sorts of wool. The "gill-boxes" have been made by Mr. Edward Deuce, and are considered by those who use them to answer the purpose well. I beg to observe that I should have approved of them if they had had a less number of "fallers up," believing, as I do, that whatever breadth of fallers you have more than the length of the wool which you have to draw, are all useless, and so much additional wear and tear.

In the carding and combing rooms we found a number of two-cylinder carding machines, which had been made in Belgium. They were of a lighter description than those made in this country, and consequently not so steady, or so well calculated

to do the work required of them. They were just commencing to work two carding machines which had been made by Thornton, Brothers, of Cleckheaton. These machines were much stronger, and in every way better arranged to answer the purpose for which they were intended.

The combs are in principle almost similar to Mr. Rawson's and Mr. Holden's; but there is another, a rather curious one, the whole of the "faller carriage" moving forward to fill the comb. The material was imbedded in the comb by a dabbing brush; the "faller-carriage" then receded, the comb drawing the wool through the fallers as it did so, and in this manner this cumbrous machine did its work. The preparing for the combs was much the same as that which we have in this country, and, therefore, I have no remark to make upon it.

Having gone through what I will call the Bradford part of the manufacture that was being carried on in this place, we were then admitted into the other part of the establishment, wherein was at work similar machinery to that which we had seen elsewhere in France.

Now, I beg leave to state that here, as at all other places we have visited, the same great care is taken that everything they do is well done. This I consider to be one of the first essentials in any manufactory, and one which, I think, ultimately tends in a great degree, together with the machinery they apply to the purpose, to account for the superiority they possess in the appearance of their highly-finished goods.

I would observe here that there is some difference between the amount of wool which is put through the machinery at Reims and the quantity they put through here at Roubaix. I cannot see the reason why they should put more through here than at Reims, because, whatever amount is put through, it has to be reduced to the spun thread at last, and I would, therefore, give my opinion in favor of the practice adopted at Reims, that of confining themselves to a less bulk of material in their first process of drawing.

Leclerq-Dupire.—This gentleman at first was not so free, and

refused altogether to have anything at all to do with us; but on entering into conversation with him, we very soon found out that he was a determined enemy to free trade. He considered that the town of Roubaix was sold, and that the treaty effected by the efforts of Mr. Cobden was inflicting serious and ruinous effects upon the manufacturing industry of France, and especially that of Roubaix.

He charged us with being commissioned to ascertain their method of business, and then return home with instructions to enable our manufactures to compete with them more successfully. Now, I am very glad to say that before we left this gentleman, he not only showed us his pieces in stock but gave us a sample, as well as recommendations to visit other places, one of which was refused, and to the other we gained admittance. I might as well here state that it was from this gentleman that we received the information that connected with the trade of the town of Roubaix there are about 15,000 power-looms and more than 200,000 hand-looms.

Our next visit was to Tourcoing. The machinery here, although made in France, was on a larger scale than any we had yet seen of the French make. The processes were much the same. They spun upon the mule: and throughout the whole of the establishment the same care was taken in all their processes that we had observed elsewhere, a characteristic feature of the French factory workpeople that has come under our observation.

Our next visit was to the manufactory of M. Seydoux and Co., at Le Catiau. This I should consider the largest manufacturing establishment in France; and at this place every attention and kindness were shown towards us by the principal partners of this firm. From the moment we entered these extensive works, which was at half-past six in the morning, to our departure, at three o'clock in the afternoon, our guide did his utmost to oblige us in every respect, by taking us through every room where the processes were going on. And here I must confess that, having been myself employed in several large firms in Bradford, and

having had frequent opportunities, in consequence of my business, of visiting other manufactories in the kingdom, I was really struck with astonishment at the cleanliness, the order, and regularity in this vast but well-arranged establishment. This is the place in which the yarn was drawn and spun to the enormous and almost incredible length of 310,000 metres to the kilogramme.*

To give you a description of the machinery would be almost to repeat what I have said with respect to Reims, but for this difference, that as they make all their own, I must confess it is of the highest order, and that no labor has been spared to adapt it to its special purpose. It would be well to mention here that the number of balls which one of their drawing-boxes delivers is sometimes four, sometimes eight, or even ten. What I would call one of their finishing-boxes delivers about twenty balls, and what I would term their "roving-frame," delivers from fifty to sixty balls, and by the material going on to the ball double, they may be called from 100 to 120 single rovings.

The machines are long, and not so wide; and, taking into consideration a set of drawings of our own make, together with the creels, it is my opinion that they could almost place two sets in the same space where we place one; and as their processes are all open drawing, and consequently not so heavily pressed as ours, it is reasonable to suppose that they will not require as much power to drive them as in those boxes where there are spindles and heavily-pressed "top rollers."

We next visited the weaving department. The weaving here is very good; some of the pieces are of the very finest description, and the looms have been made at Mr. George Hodgson's. The old process of warping is dispensed with here, as well as at Reims, as they warp upon the loom-beam from a great creel; the warp then goes through the process of sizing, and is dried by fans in its passage on to another beam. It is then taken to the twirling-frame, and after that process is gone through, it is

* Equal to 274 hanks per pound.

taken to the loom. They have at this place 320 horse-power, 1000 power-looms, 3000 hand-looms, 50,000 mule spindles, and are about to increase them to 65,000, and augment their moving power to 500 nominal horse-power.

This ends our inspection of machinery.

If an inquiry like this had been instituted twenty years ago, it might have answered a good purpose. I hope it may do so now, for you may depend upon it that every exertion is being made to supersede us altogether; and, without some great effort on our part be made, the time is not far distant when such will be the case. I have every reason to believe that men are sent over to this country, whenever they hear of anything new being adopted, to ascertain all the particulars about it; and if it be practicable, and will serve any purpose of utility, it is not long before it is adopted by them. I still, however, think that by one great effort of a united people, England may, by the determined perseverance of her enterprising spinners and manufacturers, aided by the indomitable energy of her sons of toil, win back, perhaps not her pre-eminence, but an equality, which she may successfully maintain among the nations of the earth.

TABLES

SHOWING THE

RELATIVE VALUES OF FRENCH AND ENGLISH WEIGHTS AND MEASURES, &c.

Measures of Length.

Millimetre	=	0.03937	inch.
Centimetre	=	0.393708	"
Decimetre	=	3.937079	inches.
Metre	=	39.37079	"
"	=	3.2808992	feet.
"	=	1.093633	yard.
Decametre	=	32.808992	feet.
Hectometre	=	328.08992	"
Kilometre	=	3280.8992	"
"	=	1093.633	yards.
Myriametre	=	10936.33	"
"	=	6.2138	miles.
Inch ($\frac{1}{36}$ yard)	=	2.539954	centimetres.
Foot ($\frac{1}{3}$ yard)	=	3.0479449	decimetres.
Yard	=	0.91438348	metre.
Fathom (2 yards)	=	1.82876696	"
Pole or perch ($5\frac{1}{2}$ yards)	=	5.029109	metres.
Furlong (220 yards)	=	201.16437	"
Mile (1760 yards)	=	1609.3149	"
Nautical mile	=	1852	"

Superficial Measures.

Square millimetre	=	$\frac{1}{645}$	square inch.
" "	=	0.00155	" "
" centimetre	=	0.155006	" "
" decimetre	=	15.50059	" inches.
" "	=	0.107643	" foot.
" metre or centiare	=	1550.05989	" inches.
" " "	=	10.764299	" feet.
" " "	=	1.196033	" yard
Are	=	1076.4299	" feet.
"	=	119.6033	" yards.
"	=	0.098845	rood.
Hectare	=	11960.3326	square yards.
"	=	2.471143	acres.
Square inch	=	645.109201	square millimetres.
" "	=	6.451367	" centimetres
" foot	=	9.289968	" decimetres.
" yard	=	0.836097	" metre.
" rod or perch	=	25.291939	" metres.
Rood (1210 sq. yards)	=	10.116775	ares.
Acre (4840 sq. yards)	=	0.404671	hectare.

Measures of Capacity.

Cubic millimetre	=	0.000061027	cubic inch.
" centimetre or millilitre	=	0.061027	" "
10 " centimetres or centilitre	=	0.61027	" "
100 " " " decilitre	=	6.102705	" inches.
1000 " " " litre	=	61.0270515	" "
" " " " "	=	1.760773	imp'l pint.
" " " " "	=	0.2200967	" gal'n.
Decalitre	=	610.270515	cubic inches.
"	=	2.2009668	imp. gal'ns.
Hectolitre	=	3.531658	cubic feet.
"	=	22.009668	imp. gal'ns.
Cubic metre or stere or kilolitre	=	1.30802	cubic yard.
" " "	=	35.3165807	" feet.
Myrialitre	=	353.165807	" "

Cubic inch	=	16.386176	cubic centimetres.
" foot	=	28.315312	" decimetres.
" yard	=	0.764513422	" metre.

American Measures.

Winchester or U.S. gallon (231 cub. in.)	=	3.785209	litres.
" " bushel (2150.42 cub. in.)	=	35.23719	"
Chaldron (57.25 cubic feet)	=	1621.085	"

British Imperial Measures.

Gill	=	0.141983	litre.
Pint ($\frac{1}{8}$ gallon)	=	0.567932	"
Quart ($\frac{1}{4}$ gallon)	=	1.135864	"
Imperial gallon (277.2738 cub. in.)	=	4.54345797	litres.
Peck (2 gallons)	=	9.0869159	"
Bushel (8 gallons)	=	36.347664	"
Sack (3 bushels)	=	1.09043	hectolitre.
Quarter (8 bushels)	=	2.907813	hectolitres.
Chaldron (12 sacks)	=	13.08516	"

Weights.

Milligramme	=	0.015438395	troy grain.
Centigramme	=	0.15438395	" "
Decigramme	=	1.5438395	" "
Gramme	=	15.438395	" grains.
"	=	0.643	pennyweight.
"	=	0.0321633	oz. troy.
"	=	0.0352889	oz. avoirdupois.
Decagramme	=	154.38395	troy grains.
"	=	5.64	drachms avoirdupois.
Hectogramme	=	3.21633	oz. troy.
"	=	3.52889	oz. avoirdupois.
Kilogramme	=	2.6803	lbs. troy.
"	=	2.205486	lbs. avoirdupois.
Myriagramme	=	26.803	lbs. troy.
"	=	22.05486	lbs. avoirdupois.

Quintal metrique = 100 kilog. = 220.5486 lbs. avoirdupois.
Tonne = 1000 kilog. = 2205.486 " "

VALUES OF FRENCH AND ENGLISH

Different authors give the following values for the gramme :—

Gramme	=	15.44402	troy grains.
"	=	15.44242	"
"	=	15.4402	"
"	=	15.433159	"
"	=	15.43234874	"

AVOIRDUPOIS.

Long ton = 20 cwt. = 2240 lbs.	=	1015.649	kilogrammes.
Short ton (2000 lbs.)	=	906.8296	"
Hundred weight (112 lbs.)	=	50.78245	"
Quarter (28 lbs.)	=	12.6956144	"
Pound = 16 oz. = 7000 grs.	=	453.4148	grammes.
Ounce = 16 dr'ms. = 437.5 grs.	=	28.3375	"
Drachm = 27.344 grains	=	1.77108	gramme.

TROY (PRECIOUS METALS).

Pound = 12 oz. = 5760 grs.	=	373.096	grammes.
Ounce = 20 dwt. = 480 grs.	=	31.0913	"
Pennyweight = 24 grs.	=	1.55457	gramme.
Grain	=	0.064773	"

APOTHECARIES' (PHARMACY).

Ounce = 8 drachms = 480 grs.	=	31.0913	gramme.
Drachm = 3 scruples = 60 grs.	=	3.8869	"
Scruple = 20 grs.	=	1.29546	gramme.

CARAT WEIGHT FOR DIAMONDS.

1 carat	=	4 carat grains = 64 carat parts.	
"	=	3.2	troy grains.
"	=	3.273	" "
"	=	0.207264	gramme
"	=	0.212	"
"	=	0.205	"

Great diversity in value.

Proposed Symbols for Abbreviations.

M—myria — 10000	Mm	Mg	Ml	
K—kilo — 1000	Km	Kg	Kl	
H—hecto — 100	Hm	Hg	Hl	Ha
D—deca — 10	Dm	Dg	Dl	Da
Unit — 1	metre—m	gramme—g	litre—l	are—a
d—deci — 0.1	dm	dg	dl	da
c—centi — 0.01	cm	cg	cl	ca
m—milli — 0.001	mm	mg	ml	

Km = Kilometre. Hl = Hectolitre. cg = centigramme. c. cm = $\overline{\text{cm}}^3$ = cubic centimetre. $\overline{\text{dm}}^2$ = sq. dm = square decimetre. Kgm = Kilogrammetre. Kg° = Kilogramme degree.

Celsius or Centigrade.	Fahrenheit.	Réaumur.
— 15°	+ 5°	— 12°
— 10	+ 14	— 8
— 5	+ 23	— 4
0 melting	+ 32	ice 0
+ 5	+ 41	+ 4
+ 10	+ 50	+ 8
+ 15	+ 59	+ 12
+ 20	+ 68	+ 16
+ 25	+ 77	+ 20
+ 30	+ 86	+ 24
+ 35	+ 95	+ 28
+ 40	+104	+ 32
+ 45	+113	+ 36
+ 50	+122	+ 40
+ 55	+131	+ 44
+ 60	+140	+ 48
+ 65	+149	+ 52
+ 70	+158	+ 56
+ 75	+167	+ 60
+ 80	+176	+ 64
+ 85	+185	+ 68
+ 90	+194	+ 72
+ 95	+203	+ 76
+100 boiling	+212	water + 80
+200	+392	+160
+300	+572	+240
+400	+752	+320
+500	+932	+400

$$1^\circ \text{ C.} = 1^\circ.8 \text{ Ft.} = \tfrac{9}{5}{}^\circ \text{ Ft.} = 0^\circ.3 \text{ R.} = \tfrac{4}{5}{}^\circ \text{ R.}$$

1° C. $\times \frac{9}{5} = 1^\circ$ Ft. $\quad 1^\circ$ Ft. $\times \frac{5}{9} = 1^\circ$ C. $\quad 1^\circ$ R. $\times \frac{9}{4} = 1^\circ$ Ft.

1° C. $\times \frac{4}{5} = 1^\circ$ R. $\quad 1^\circ$ Ft. $\times \frac{4}{9} = 1^\circ$ R. $\quad 1^\circ$ R. $\times \frac{5}{4} = 1^\circ$ C.

$$\text{Calorie (French)} \left.\begin{array}{l} = \text{unit of heat} \\ = \text{kilogramme degree} \end{array}\right\} \text{English.}$$

It is the quantity of heat necessary to raise 1° C. the temperature of 1 kilogramme of distilled water.

Kilogrammetre = Kgm = the power necessary to raise 1 kilogramme, 1 metre high, in one second. It is equal to $\frac{1}{75}$ of a French horse power. An English horse power = 550 foot pounds, while a French horse power = 542.7 foot pounds.

Ready-made Calculations.

No. of units.	Inches to centimetres.	Feet to metres.	Yards to metres.	Miles to Kilometres.	Millimetres to inches.
1	2.53995	0.3047945	0.91438348	1.6093	0.03937079
2	5.0799	0.6095890	1.82876696	3.2186	0.07874158
3	7.6199	0.9143835	2.74315044	4.8279	0.11811237
4	10.1598	1.2197680	3.65753392	6.4373	0.15748316
5	12.6998	1.5239724	4.57191740	8.0466	0.19685395
6	15.2397	1.8287669	5.48630088	9.6559	0.23622474
7	17.7797	2.1335614	6.40068436	11.2652	0.27559553
8	20.3196	2.4383559	7.31506784	12.8745	0.31496632
9	22.8596	2.7431504	8.22945132	14.4838	0.35433711
10	25.3995	3.0479450	9.14383480	16.0930	0.39370790

No. of units.	Centimetres to inches.	Metres to feet.	Metres to yards.	Kilometres to miles.	Square inches to square centimetres.
1	0.3937079	3.2808992	1.093633	0.6213824	6.45136
2	0.7874158	6.5617984	2.187266	1.2427648	12.90272
3	1.1811237	9.8426976	3.280899	1.8641472	19.35408
4	1.5748316	13.1235968	4.374532	2.4855296	25.80544
5	1.9685395	16.4044960	5.468165	3.1069120	32.25680
6	2.3622474	19.6853952	6.561798	3.7282944	38.70816
7	2.7559553	22.9662944	7.655431	4.3496768	45.15952
8	3.1496632	26.2471936	8.749064	4.9710592	51.61088
9	3.5433711	29.5280928	9.842697	5.5924416	58.06224
10	3.9370790	32.8089920	10.936330	6.2138240	64.51360

No. of units.	Square feet to sq. metres.	Sq. yards to sq. metres.	Acres to hectares.	Square centimetres to sq. inches.	Sq. metres to sq. feet.
1	0.0929	0.836097	0.404671	0.155	10.7643
2	0.1858	1.672194	0.809342	0.310	21.5286
3	0.2787	2.508291	1.204013	0.465	32.2929
4	0.3716	3.344388	1.618684	0.620	43.0572
5	0.4645	4.180485	2.023355	0.775	53.8215
6	0.5574	5.016582	2.428026	0.930	64.5858
7	0.6503	5.852679	2.832697	1.085	75.3501
8	0.7432	6.688776	3.237368	1.240	86.1144
9	0.8361	7.524873	3.642039	1.395	96.8787
10	0.9290	8.360970	4.046710	1.550	107.6430

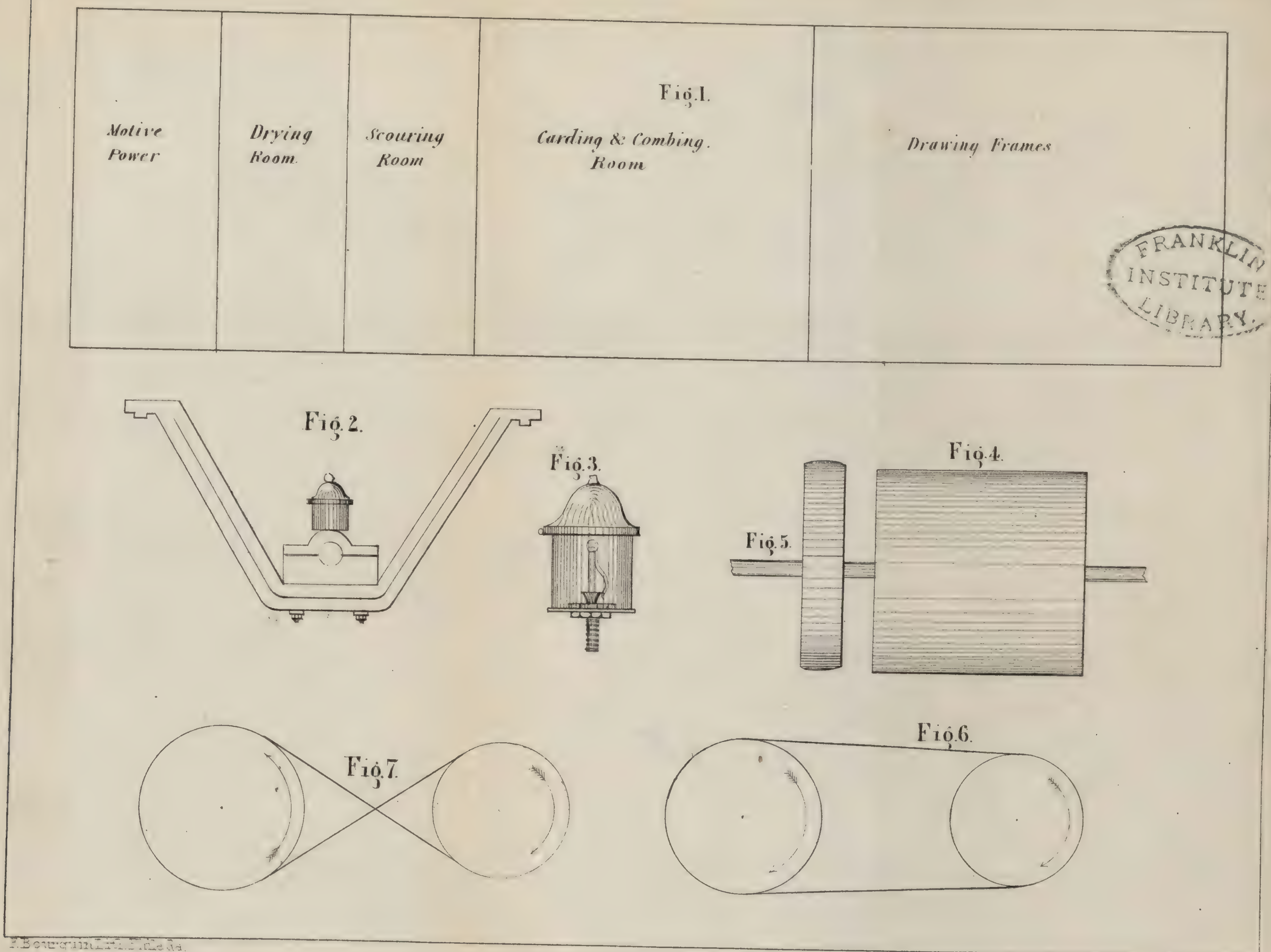
No. of units.	Square metres to sq. yards.	Hectares to acres.	Cubic inches to cubic centimetres.	Cubic feet to cubic metres.	Cubic yards to cubic metres.
1	1.196033	2.471143	16.3855	0.02831	0.76451
2	2.392066	4.942286	32.7710	0.05662	1.52902
3	3.588099	7.413429	49.1565	0.08494	2.29354
4	4.784132	9.884572	65.5420	0.11325	3.05805
5	5.980165	12.355715	81.9275	0.14157	3.82257
6	7.176198	14.826858	98.3130	0.16988	4.58708
7	8.372231	17.298001	114.6985	0.19819	5.35159
8	9.568264	19.769144	131.0840	0.22651	6.11611
9	10.764297	22.240287	147.4695	0.25482	6.88062
10	11.960330	24.711430	163.8550	0.28315	7.64513

No. of units.	Cubic centimetres to cubic inches.	Litres to cubic inches.	Hectolitres to cubic feet.	Cubic metres to cubic feet.	Cubic metres to cubic yards.
1	0.06102	61.02705	3.5317	35.31659	1.30802
2	0.12205	122.05410	7.0634	70.63318	2.61604
3	0.18308	183.08115	10.5951	105.94977	3.92406
4	0.24411	244.10820	14.1268	141.26636	5.23208
5	0.30514	305.13525	17.6585	176.58295	6.54010
6	0.36617	366.16230	21.1902	211.89954	7.84812
7	0.42720	427.18935	24.7219	247.21613	9.15614
8	0.48823	488.21640	28.2536	282.53272	10.46416
9	0.54926	549.24345	31.7853	317.84931	11.77218
10	0.61027	610.27050	35.3166	353.16590	13 08020

No. of units.	Grains to grammes.	Ounces avoir. to grammes.	Ounces troy to grammes.	Pounds avoir. to kilogrammes.	Pounds troy to kilogrammes.
1	0.064773	28.3375	31.0913	0.4534148	0.373096
2	0.129546	56.6750	62.1826	0.9068296	0.746192
3	0.194319	85.0125	93.2739	1.3602444	1.119288
4	0.259092	113.3500	124.3652	1.8136592	1.492384
5	0.323865	141.6871	155.4565	2.2670740	1.865480
6	0.388638	170.0250	186.5478	2.7204888	2.238576
7	0.453411	198.3625	217.6391	3.1739036	2.611672
8	0.518184	226.7000	248.7304	3.6273184	2.984768
9	0.582957	255.0375	279.8217	4.0807332	3.357864
10	0.647730	283.3750	310.9130	4.5341480	3.730960

No. of units.	Long tons to tonnes of 1000 kilog.	Pounds per square inch to kilogrammes per square centimetre.	Grammes to grains.	Grammes to ounces avoir.	Grammes to ounces troy.
1	1.015649	0.0702774	15.438395	0.0352889	0.0321633
2	2.031298	0.1405548	30.876790	0.0705778	0.0643266
3	3.046947	0.2108322	46.315185	0.1058667	0.0964899
4	4.062596	0.2811096	61.753580	0.1411556	0.1286532
5	5.078245	0.3513870	77.191975	0.1764445	0.1608165
6	6.093894	0.4216644	92.630370	0.2117334	0.1929798
7	7.109543	0.4919418	108.068765	0.2470223	0.2251431
8	8.125192	0.5622192	123.507160	0.2823112	0.2573064
9	9.140841	0.6324966	138.945555	0.3176001	0.2894697
10	10.156490	0.7027740	154.383950	0.3528890	0.3216330

No. of units.	Kilogrammes to pounds avoirdupois.	Kilogrammes to pounds troy.	Metric tonnes of 1000 kilog. to long tons of 2240 pounds.	Kilog. per square millimetre to pounds per square inch.	Kilog. per square centimetre to pounds per square inch.
1	2.205486	2.6803	0.9845919	1422.52	14.22526
2	4.410972	5.3606	1.9691838	2845.05	28.45052
3	6.616458	8.0409	2.9537757	4267.57	42.67578
4	8.821944	10.7212	3.9383676	5690.10	56.90104
5	11.027430	13.4015	4.9229595	7112.63	71.12630
6	13.232916	16.0818	5.9075514	8535.15	85.35156
7	15.438402	18.7621	6.8921433	9957.68	99.57682
8	17.643888	21.4424	7.8767352	11380.20	113.80208
9	19.849374	24.1227	8.8613271	12802.73	128.02734
10	22.054860	26.8030	9.8459190	14225.26	142.25260



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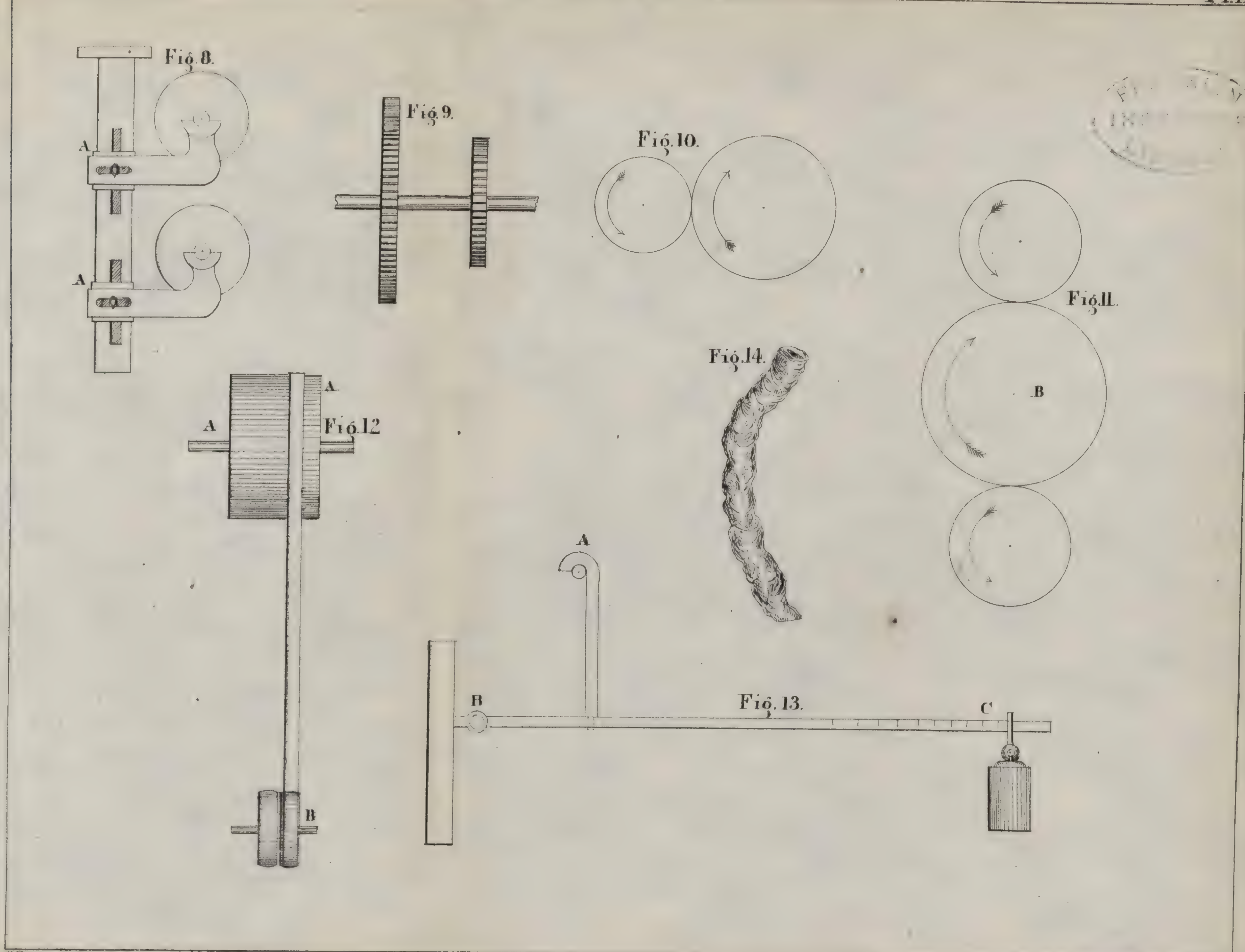
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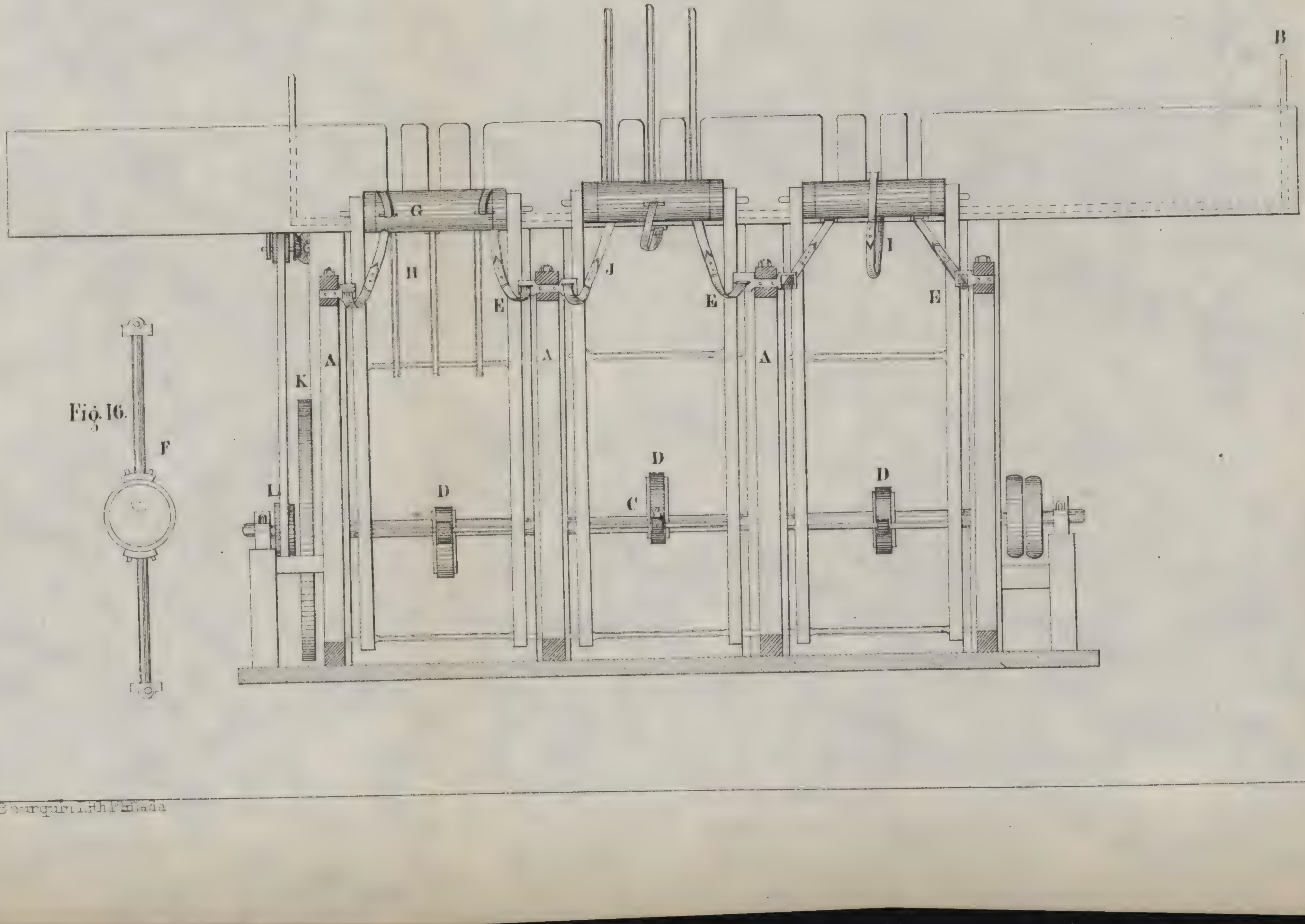

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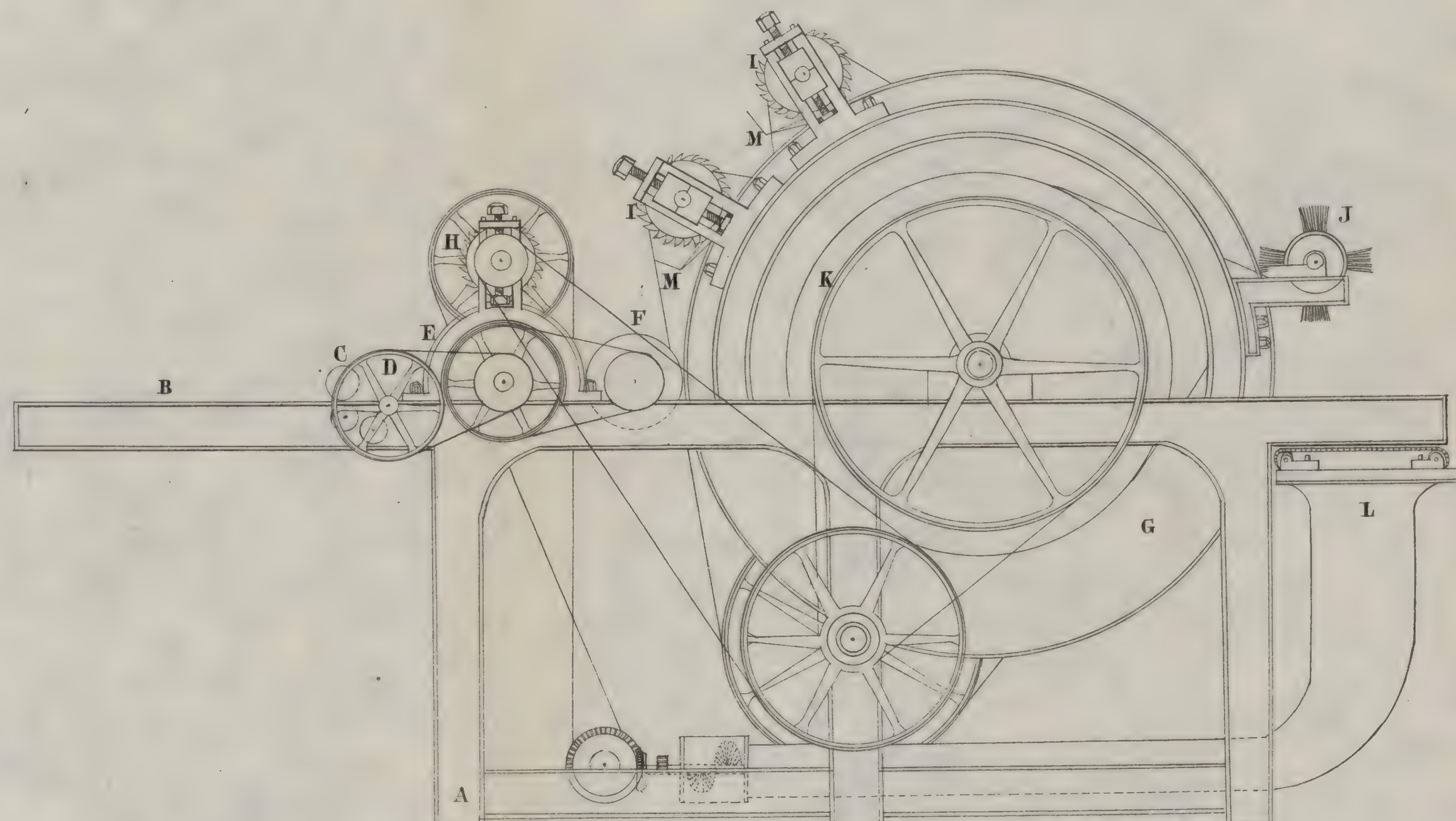
Fig. 17.



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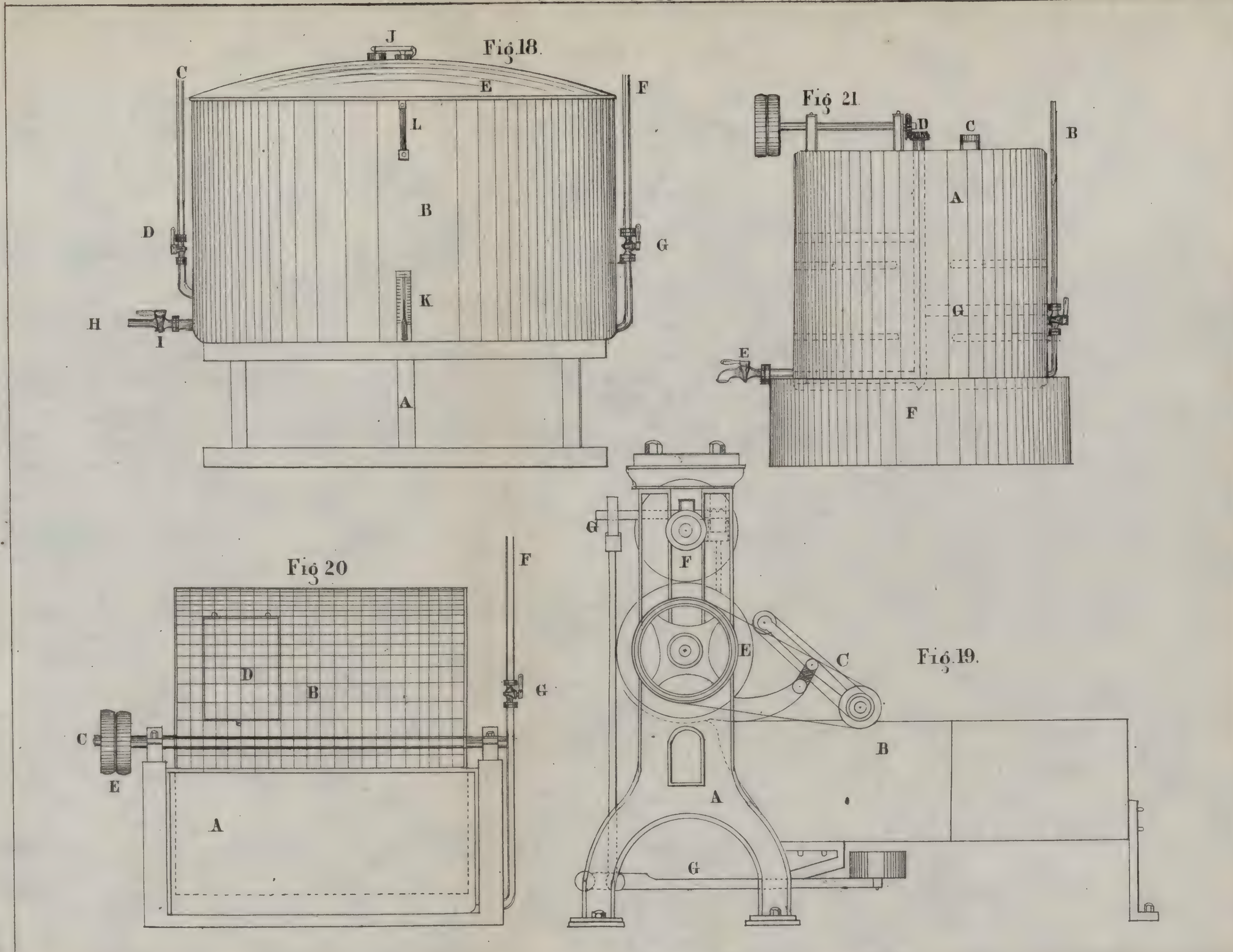

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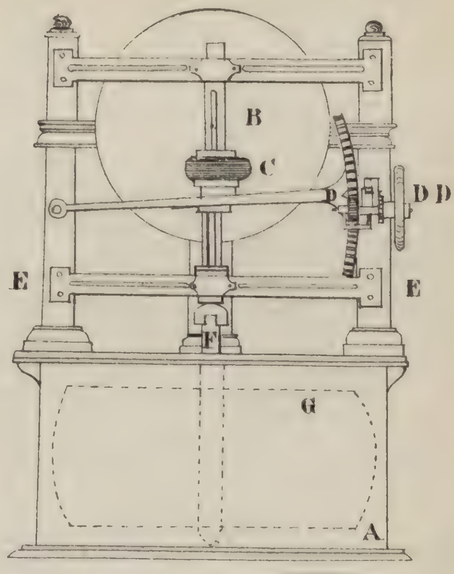

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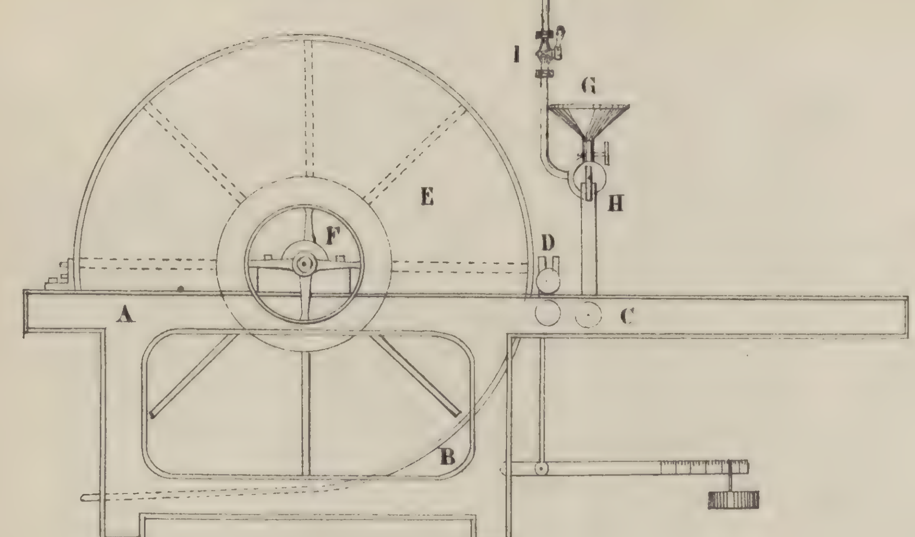

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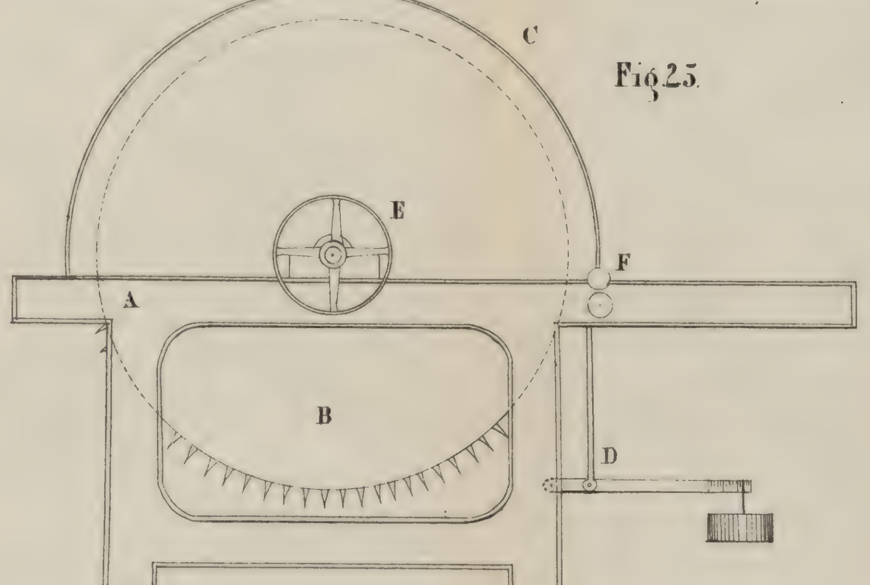

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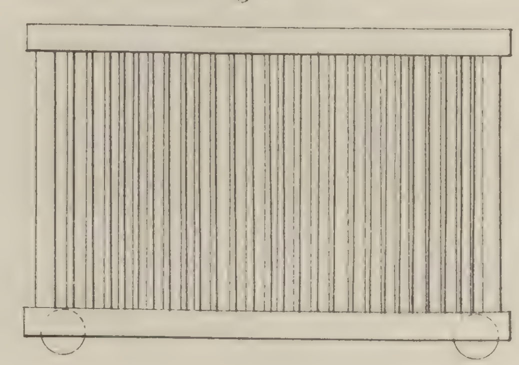

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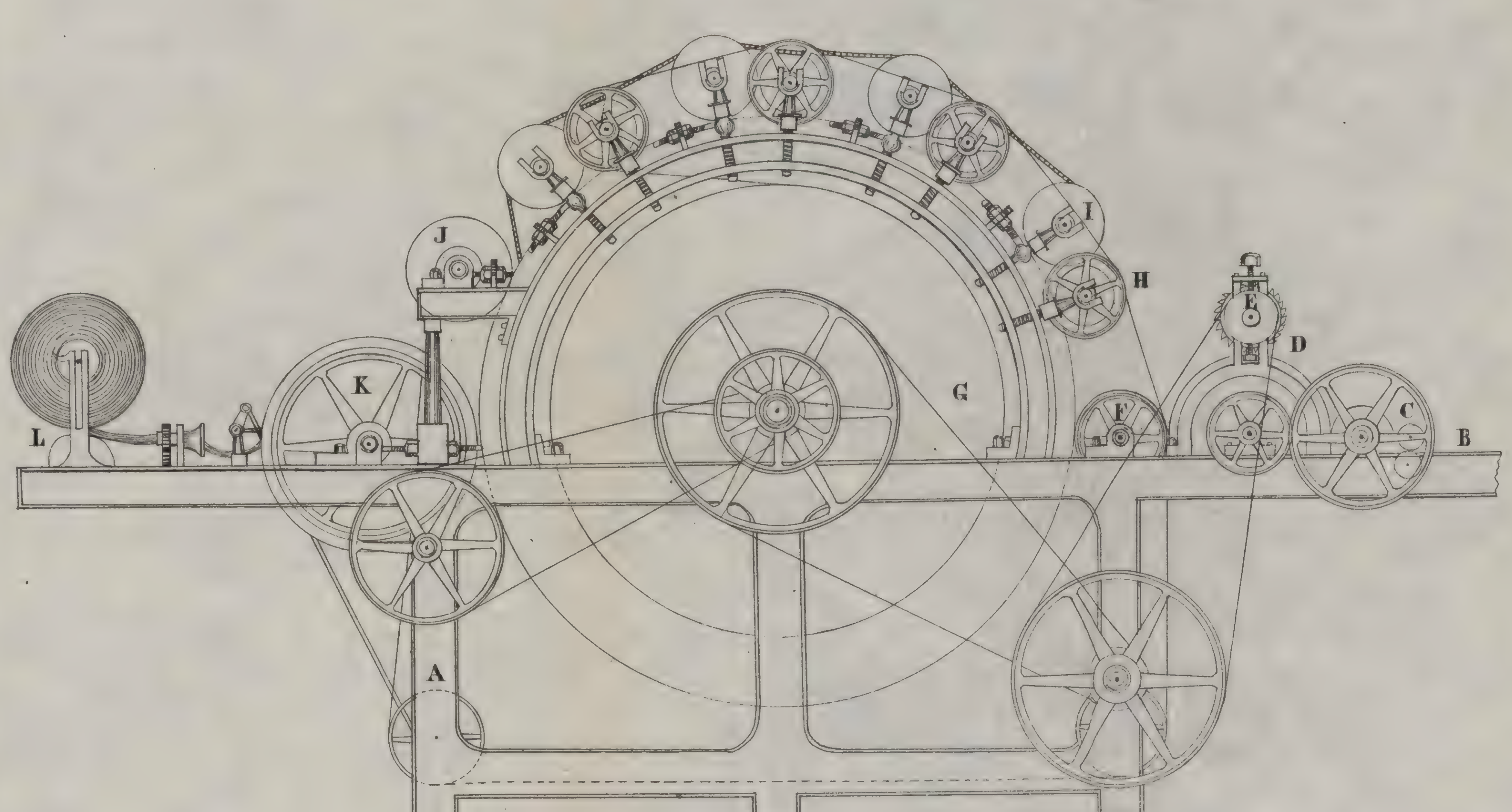

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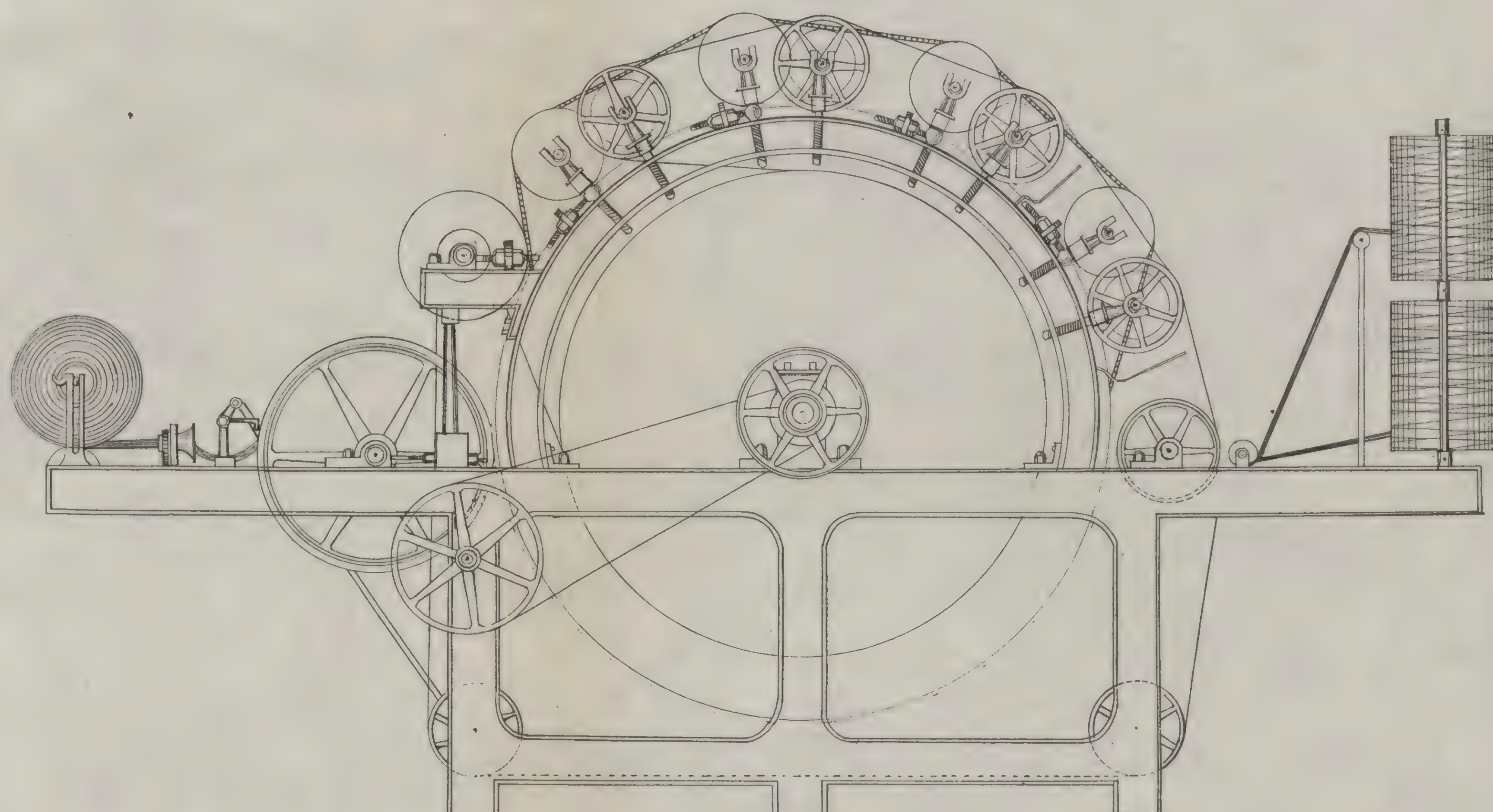

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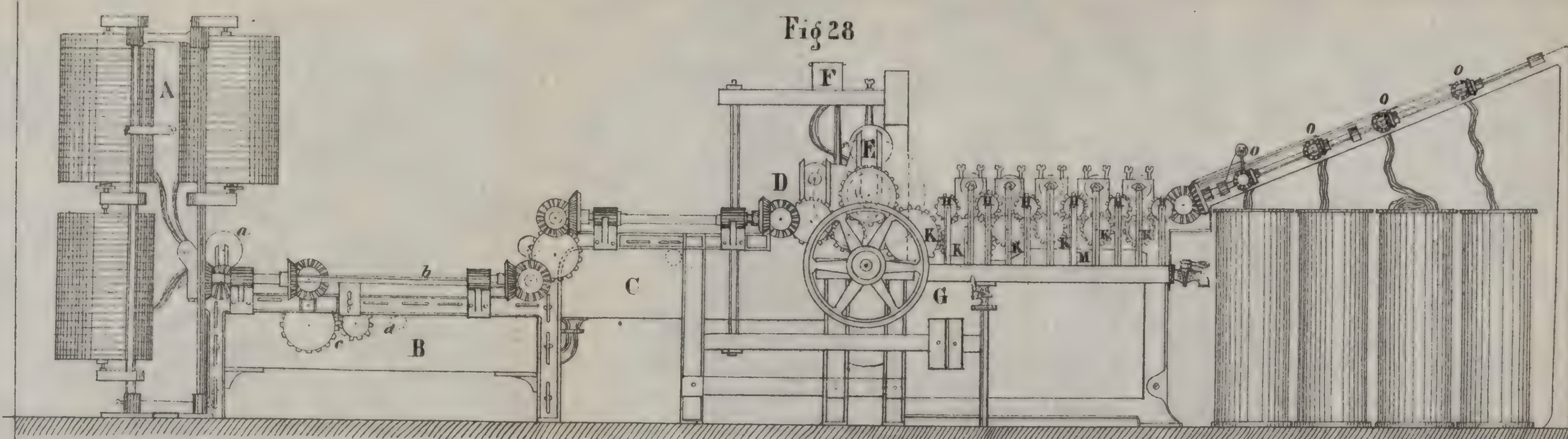
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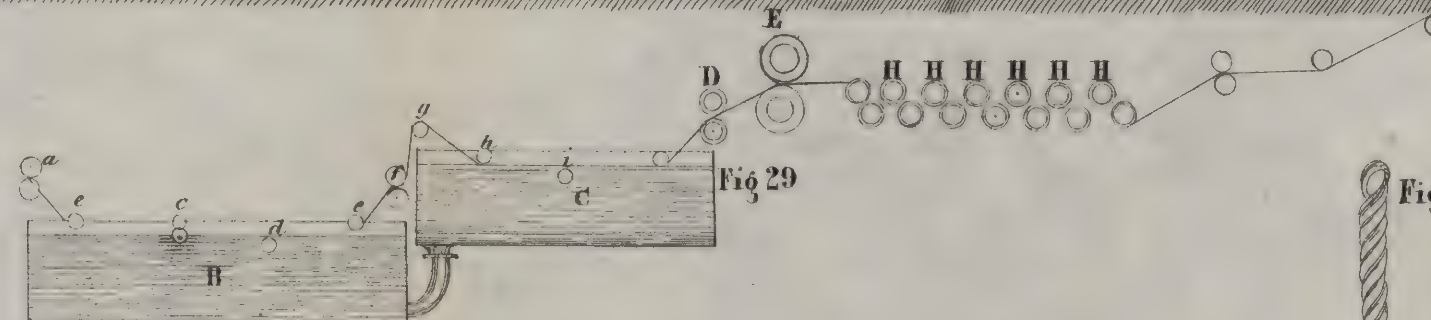
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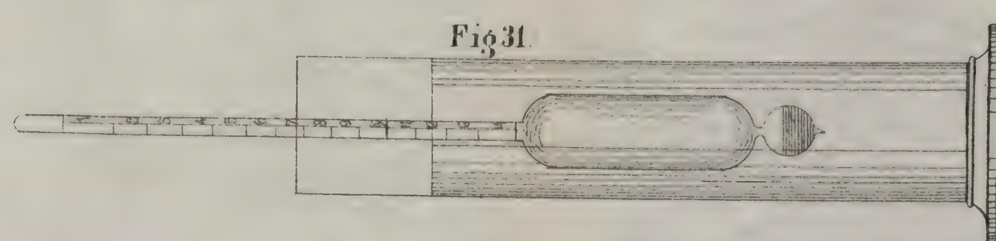
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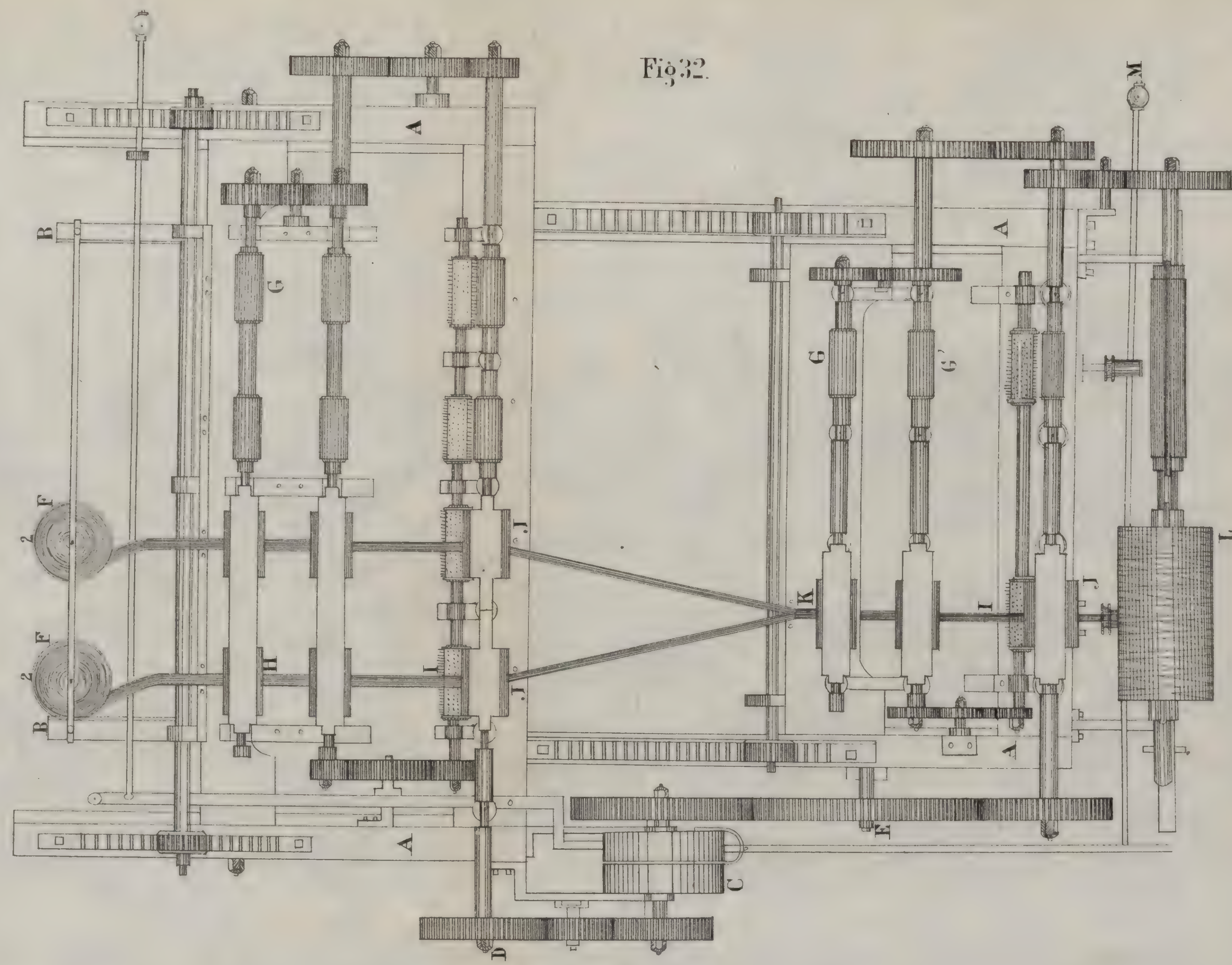

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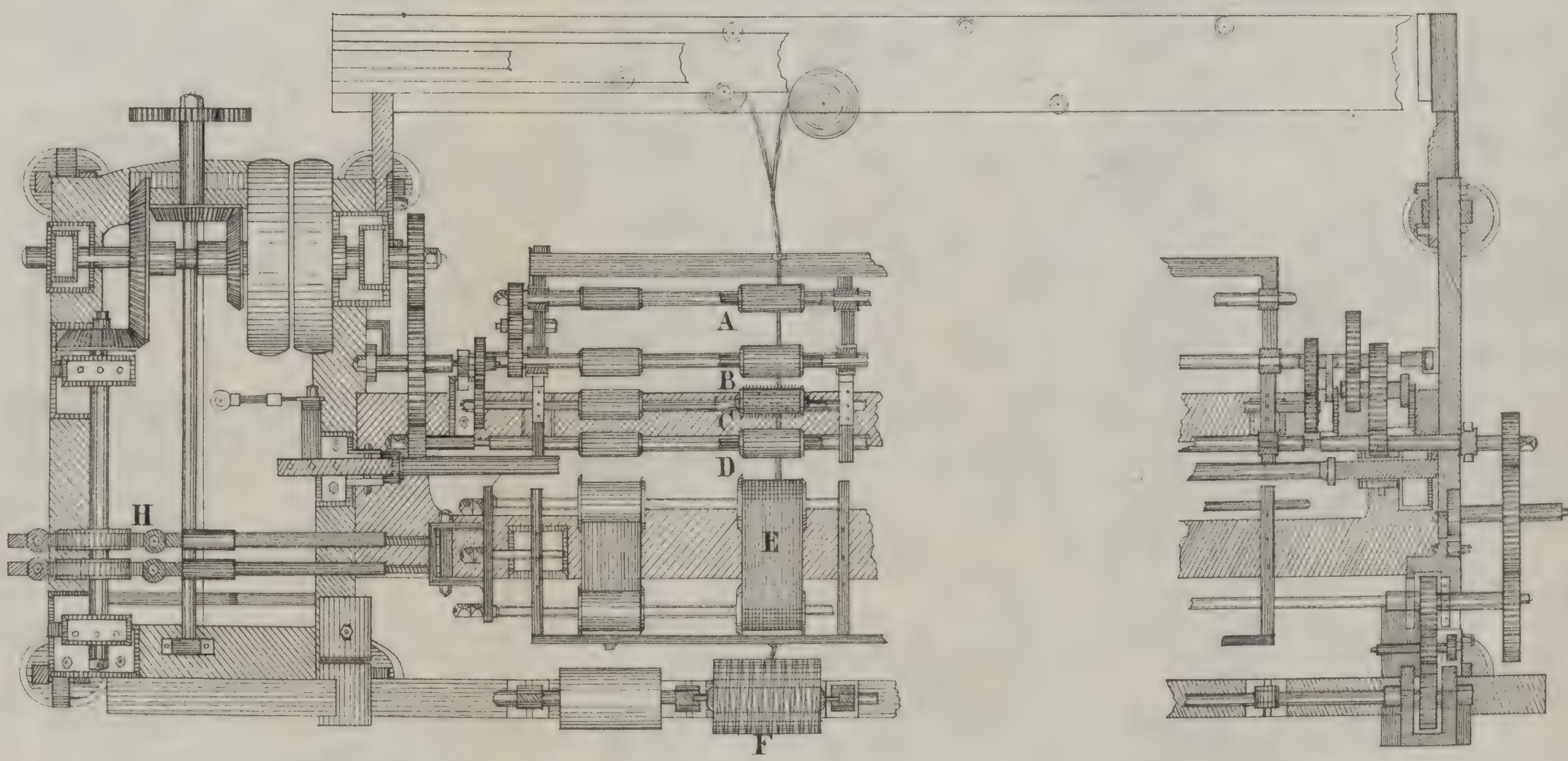

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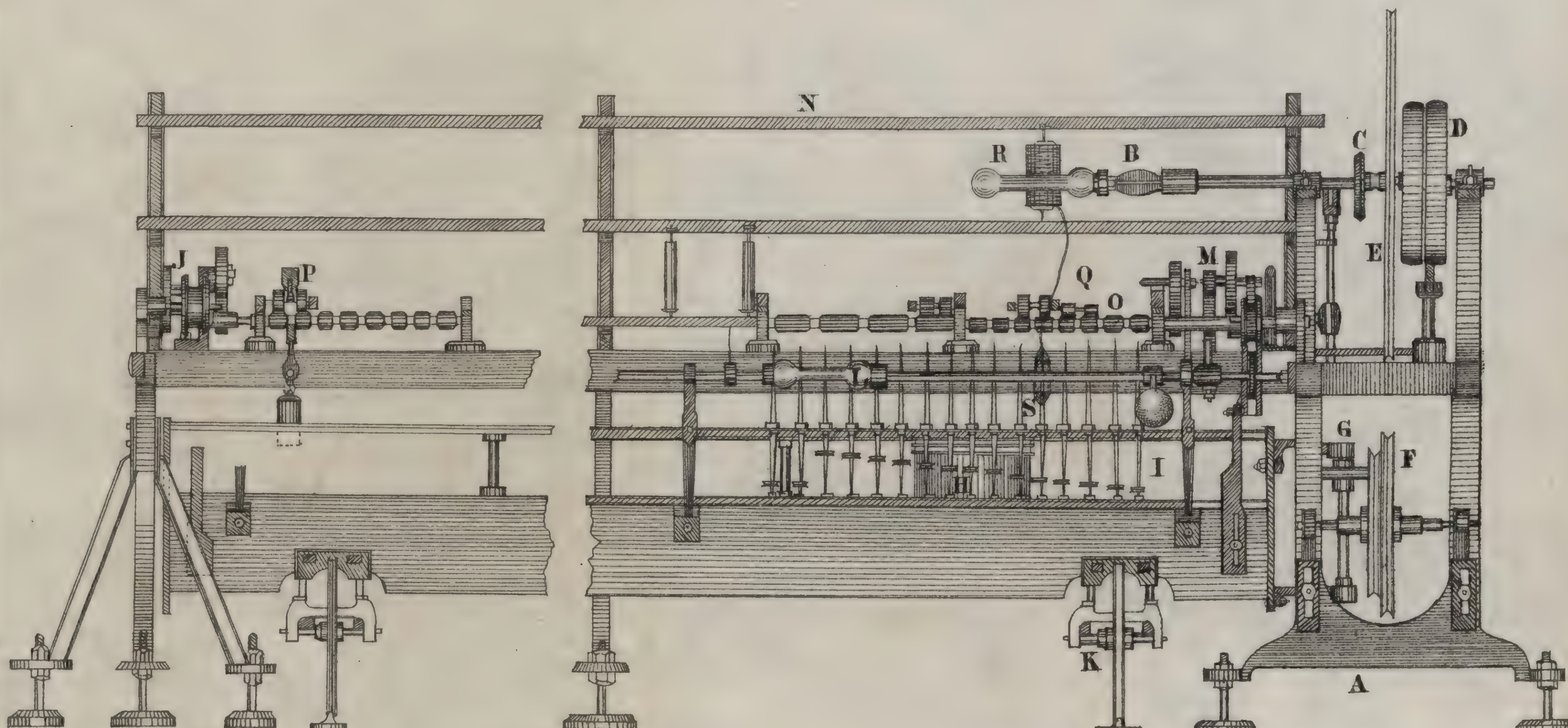

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* These addresses are given at the end of Mr. Leroux's book, and it has been deemed desirable to retain them in this edition, as it is believed that among the more enterprising American, Canadian, and English manufacturers there may be found those who will wish to put themselves in communication with some of the parties here named.

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